Human Safety at EMU Registrar Office

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ABSTRACT

In this research study, the safety issues of a specific work place environment was studied. The registration department at the Eastern Mediterranean University was selected as the field of study. The physical hazards and human factors in the workplace environment were focused and chosen, anthropometric measurements, illumination rates, sound level pressure, and the equipments used by the staff of that department were analyzed and studied. Additionally, the effects of working conditions on the safety and health of the personnels of this department were explored.

This study is very important to address the existing problems for the selected work place to establish safety rules recommendations to avoid risks or hazards that the staff of the department is subject to.

Twenty employees from registration department were selected and participated in this study, there ages between 19 and 56 years old. Fifteen kinds of anthropometric and physical measurements were used, twelve type of vision and sight were done parallel to the measurements of illumination levels at 32 position of the whole place in the ground floor of EMU registrar office, consequently, the air conduction test was applied to recognize the degree of hearing loss for all employees at EMU registrar office, in addition to the sound level pressure at each place and corner of the registration office.

The staff of registration department was informed at the beginning that human safety is the main issue of this research.

All personnel should have a safe working environment in which every employed person health is well maintained and should not be subject to any hazard.

The anthropometric measurements were including: body height, shoulder height, shoulder elbow height, buttock-to-popliteal length, deviation, percentiles, minimum and maximum value of anthropometric dimensions, popliteal height, knee height, forearm length, hip width, elbow sitting height, sitting height, sitting eye height and overhead stretch height. The mean, Standard deviation, percentiles, minimum and maximum value of anthropometric dimensions were calculated.

The results of study showed that there are significant differences between male and female body dimensions, and there is a negative effect on vision and hearing.

The current layout was found to fail to comply with ergonomy design criteria. A new design of furniture was proposed to improve the level of comfort.

Keywords: Human Safety, Anthropometric, Illumination, Noise, and Hazards.

ÖZ

Bu araştırmada belirli bir işyeri ortamının güvenlik konuları üzerinde durulacaktır. Doğu Akdeniz Üniversitesi kayıt bölümü çalışma alanı olarak seçilmiştir. İşyeri ortamındaki fiziksel tehlikeler ve insan faktörleri üzerinde durulacak, seçilecek, antropometrik ölçümler, aydınlatma oranları, ses düzeyi basıncı ve o bölüm personeli tarafından kullanılan ekipmanlar analiz edilecek ve incelenecektir. Çalışmada işyeri ortamındaki fiziksel tehlikeler ve insan faktörleri üzerinde durulacak, seçilen antropometrik ölçümler, aydınlatma oranları, ses düzeyi basıncı ve o bölüm personeli tarafından kullanılan ekipmanlar analiz edilip ve incelenecektir. Ek olarak, çalışma koşullarının bu bölümdeki personelin güvenliği ve sağlığı üzerindeki etkileri araştırılacaktır.

Bu çalışma, seçilen işyerinde, bölüm personelinin tabi olduğu riskleri veya tehlikeleri önlemek, güvenlik kuralları için tavsiyeler oluşturmak ve mevcut sorunları gidermek için çok önemlidir.

Kayıt bölümünden yaşları 19 ile 56 arasında değişen 20 çalışan seçilmiş ve çalışmaya katılmıştır. On beş değişik antropometrik ve fiziki ölçüm bu çalışmada kullanılmış, DAÜ kayıt ofisinin zemin katındaki tüm yerin 32'inci konumundaki aydınlatma seviyelerinin ölçümüne paralel olarak on iki görme ve görüş gözlemi yapılmış ve hava iletimi testi ofisteki tüm çalışanların işitme kayıp derecesini ve kayıt ofisinin her bir noktasındaki ses düzeyi baskısını tanınması için uygulanmıştır.

Kayıt bölümünün personeli, bu araştırmanın ana konusunun insan güvenliği olduğu hakkında bilgilendirildi.

Tüm personelin, sağlık durumlarının iyi korunduğu ve herhangi bir tehlikeye maruz kalmayacağı güvenli bir çalışma ortamına sahip olması gerekir.

Antropometrik ölçümler: vücut yüksekliği, omuz yüksekliği, omuz dirsek yüksekliği, kalça-popliteal uzunluğu, sapma, yüzdelikler, antropometrik boyutların minimum ve maksimum değeri, popliteal yükseklik, diz yüksekliği, önkol uzunluğu, kalça genişliği, dirsek oturma yüksekliği , oturma yüksekliği, oturma göz yüksekliği ve havai esneme yüksekliğini içermektedir. Antropometrik boyutların ortalama, standart sapma, yüzde, minimum ve maksimum değerleri hesaplandı.

Çalışmanın sonuçları erkek ve bayan vücut ölçüleri arasında önemli farklar bulunduğunu ve bunun görme ile işitme üzerinde olumsuz etkileri olduğunu göstermiştir.

Mevcut düzen, ergonomi tasarım kriterlerine uymadığı tespit edildi. Konfor seviyesini iyileştirmek için yeni bir mobilya tasarımı önerildi.

Anahtar kelimeler: İnsan Güvenliği, Antropometrik, Aydınlatma, Gürültü ve Tehlikeler.

To My Family

My Father and My Mother

My Wife and Daughters

My Brother and Sisters

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Chapter 1

INTRODUCTION

The registration department is one of the most important departments in the universities. It forms the core of the administrative process in preserving and coordinating data, information and official documents for students in all disciplines, programs and colleges. This is the official aspect that keeps records, documents and student files.

The staff in this department make great efforts to maintain the accuracy of work, arrange and save student files, and organize the link between the student and all the academic and administrative departments at the university.

Staff are exposed to all the environmental factors surrounding them on a daily basis and are affected by these conditions that are reflected in their health and safety. In order to maintain the work flow, a safe working environment free from any physical hazards and the principle of occupational safety and health in the workplace should be applied.

It is essential to organize and plan the workplace well, where many employees and students spend a large part of their daily times. The furniture is used basically as a means of rest and adaptation. Usually, the fitness and quality of used furniture such as chairs, tables and stationery are not taken into consideration, and it is not surprising that this is due to the lack of a reference database for the required furniture specifications.

The EMU Registrar office environment can be defined as a system which includes the following components:

- Furniture such as tables, seats, shelves, cupboards and other work surface.
- Computer equipment such as screen, keyboard, CPU and mouse device.
- Environment factors such as illumination, glare, temperature, noise, ventilation, humidity, and the distribution of places and spaces.
- Others, for example mobiles and phones.

We know that the bodies of employees face many important effects, without being aware of them, for example, wrists, subjected to cumulative pressure that causes muscle strain and joint pain, or looking at the students and listening to them, leads to pressure on the neck and shoulders, also, sitting on the chair for a long time causes pain in the lower back, especially if the feet and legs are not relaxed and lifted from the ground level.

Such conditions can lead to cumulative physical and musculoskeletal problems or recurrent injuries from stress, which can affect human health, cause more pain, muscle fatigue, or loss of sensation, increase the chance of early occupational disease, cause poor performance, and delay completion of work and low quality.

We know the aim of human safety as a science which is to reduce all risk factors such as strain, fatigue, and injuries of human by improving the product design and workspace arrangement. It has always claimed a comfortable design and relaxed posture. Therefore, in the EMU Registrar Office workstation design, it is important to use anthropometric measures.

In the outline, we require measurements such a sitting elbow height, shoulder height, knee height, upper arm length, sitting height, popliteal height and buttock-to- popliteal length. Moreover, to assess the degree of success in product design we can determine the degree of fitness to human body dimensions which we called "mismatch ratio".

This mismatch may affect the administrative workflow, and can produce some musculoskeletal disorders, such as neck and lower back pain. Based on the above, it is possible to rely on the dimensions of furniture at the university and to consider them as a reference and compare them with the results of tests for employees. We hypothesized that this would give uncomfortable and tiring sitting positions to the majority of the staff at EMU registrar office.

The main objective of the research thesis is to assess the working environment and to examine occupational safety and health standards in the EMU Registration Department. The main aspects of occupational safety were examined, measured, analyzed and proposed solutions were developed. My methodology was following five steps during research, which is starting firstly from primary questionnaire. Secondly, conduct anthropometric measurements for all employees and measure dimensions of the used furniture during work, such as seats and tables, a complete survey of the various body dimensions was done inside registrar office for all of the employee, for example we measured the height, shoulders height, width of the buttocks, height of the legs on the ground, elbow length, arm length, etc. Those measurements are called anthropometric measurements, and we gather this information to compare it with the dimensions of seats and tables. Thirdly, measuring illumination and noise in 32 places inside the workstation of EMU Registrar Office. Fourthly, examine the vision of the staff and the safety of the eyes by visual optic testing. finally, Check the hearing loss level by using the Audiometer and Audiogram results.

This thesis consists of six chapters; the introduction was the first chapter. In chapter two I present a literature review about workstation design of seats and tables, and the physical human factors as illumination and noise. The methodology which is used, in the chapter three, the collection of the anthropometric and physical measurements from employees at Eastern Mediterranean University (EMU) is discussed. Additionally, the experimental design is considered in chapter four. After that, the results are analyzed and discussed in chapter five. Finally, discussion of my recommendation and future work and conclusion.

Chapter 2

LITERATURE REVIEW

We cannot imagine any university in the world without a department that keeps students' records and documents, issues official documents and certificates, and regulates the process of admissions and enrollment in the different disciplines of the university.

In fact, employees spend long hours each day in their offices either in front of the computer screen or just writing or working by sitting on a chair in front of a table without thinking about the resulting health impact.

Many of the studies carried out by researchers and former experts dealt with human safety and the problems faced by workers in the work environment. Many of these studies were specialized in anthropometric and suitability of working furniture for the comfort of the worker, and some studies focused on the physical hazards in the work environment such as noise and lack of lighting and their impact on hearing and sight.

2.1 Workplace Design and Anthropometric

The outline of the working environment is liable to the information and materials required for the operation of the work, including seats, tables and PCs, including a console and screen, and all the furniture utilized by the worker and his/her work. Elements of lighting, sound, ventilation, pressure and heat are also considered as physical factors for the environment and work hazards.

In a National family unit overview crosswise over Extraordinary England in 1995, it was evaluated that roughly 506,000 individuals had encountered business related musculoskeletal issue (influencing the neck or upper appendages) in the past a year that were caused or exacerbated by work (Jones et al., 1998).

Most frequent human body discomfort during sitting has appeared in the neck (37%), followed by lumbar zone (18%), and a little less in buttocks, dorsal zone and thighs (< 10%). Other zone pains are present in < 5% of the cases (Vergara, M., & Page, A. (2002).

Murphy et al. (2009) said a mismatch between the physical requirements of a job and the physical capacity of a worker can result in musculoskeletal disorders.

(Timoteo and Afininda, 2010) dissected the workstation of Filipino clients. Where the investigation demonstrated that the improper outline of furniture caused the health issues of laborers. The present workstation configuration does not suit the normal Filipino clients were their decision.

Ache and pain are the most common types of discomforts in all body regions during sitting for computer users. The discomforts were more pronounced at neck, shoulder, upper back, hand/wrist, and lower back regions (Korhan, O., & Mackieh, A. (2010)

Assessments of a work area situate set are utilized at Chulalongkorn University. By utilizing connected measurements with streamlining, it was found thus that 9% of clients are coordinating with situate stature and 36.3% of clients are coordinating for work area tallness. Also, the conclusion was that the most advantageous statures both for seat and work area were (40.5 cm and 62 cm) rather than (47.7 cm and 75 cm) which were flow utilized. The rate of coordinating was expanded by proposing these new measurements to 63.4% for situate stature and 98% for work area tallness (Angusmalin, 2010).

This study focus on the proper workstation design to reduce noisy, visual and musculoskeletal discomfort at EMU registrar office, and conserve the health and human safety for the employees.

2.2 Sitting

It is assessed that 75% of work in industrialized nations is performed while sitting (Croney, 1971). Target estimations of stances and other biomechanical and physiological variables have been additionally generally used to examine their association with various seat highlights (Anderson et al., 1979; Mandal, 1986; Nordin et al., 1986; Otun and Anderson, et al., 1988).

The part of a seat backrest is to lessen the burdens applied on the vertebral segment by unwinding the erector spinae musculature, while keeping up lumbar lordosis and expanding solace (Corlett and Eklund, 1984).

In the assessment of seats, distinctive strategies have been utilized to gauge comfort: anthropometry, subjective appraisal and target estimations, for example, postural, biomechanical and physiological parameters. Anthropometry is valuable to characterize most useful measurements of seats, yet it doesn't help with different elements influencing solace, for example, shape or slant of seat dish and backrest (Bishu et al., 1991).

More precisely, (Callahan, 2004) broke down the advantage of seat arms is to help with emptying the spine as the body weight movements to the aspect joints and causing a prolongation of tallness. The rest of workers' feet on the floor or on a footrest should be allowed by the chair height. Additionally, the chair height should allow the worker to use a suitable keyboard while keeping his/her forearm parallel to the floor and his/her wrists at the same plane of the forearm, and his/her legs should have enough clearance (Callahan, 2004).

Sitting is a method for changing stance and bringing rest by a seat like that is shown in figure 2.3 below. Sitting on an office work seat assumes an essential part in the field of work (Frumkin, H., Geller, R. J., Rubin, I. J. and Nodvin, J. (2006).

Backrests ought to be movable in tilting no less than 85 degrees to 100 degrees while still it is conceivable to keep up no less than a 90 degree sitting point and have the movability for tallness between 16 to 20 crawls from the seat container. Also, it ought to be no less than 13 inches (33 cm) wide (EOHSS, 2008).

The optimal adjustability range for seat height be 37cm to 55cm (Healthcare Ergonomics, 2012). The continuous pressure on body regions such as hand, forearm, neck, and shoulder, upper and lower back during working with computer can lead to musculoskeletal discomfort (Korhan, O., & Davari, M. 2013).

Workers spend about six to eight hours per day sitting down while doing their institution work. Mismatch between anthropometric dimensions and consumer products may cause health problems in human body. (Adu, G., Adu, S., Effah, B., & Anokye, R. 2014).

2.3 Mismatch Between Anthropometric measures and office furniture

The mismatch between anthropometric dimensions and consumer products may cause such health problems in human body as musculoskeletal disorders, concentration deficit (Bendix T,1987).

Field, D. characterized anthropometrics as a science that reviews near measurements of the human body, to touch base at the underlying scale and measurements of a household item. Particular estimations, for example, popliteal height, butt cheek to popliteal length are essential keeping in mind the end goal to decide the measurements of office furniture that will empower specialists to keep up the right sitting stance. Anthropometric information is one of the basic factors in outlining machines and gadgets (Mebarki, B. also, Davies, B.T., 1990).

A seat pan that is too wide or too profound may keep the sitter from exploiting armrests and backrest (Jackson, A. furthermore, Day, D. J. ,1996). A seat is the primary thing of a workstation that gives customizability to comfort and empowers the work statures to be controlled (Worksafe Victoria, 2006).

A profound seat will keep the seat once more from being utilized as a backrest or, if the backrest is utilized, the seat edge puts weight on the legs. Such weight can diminish dissemination in the veins and confine the nerves near the surface in the touchy region behind the knee (Corlett, E. N., 2006)

2.4 Illumination

Lighting in a workplace may impact both proficiency and visual comfort (Weston, 1962; Hopkinson and Collins, 1970; Grandjean, 1987; Begemann et al., 1997; ISO, 1997; IESNA, 2000; Knez and Kers, 2000; CIE, 2001). These issues have turned out to be more evident in late decades in light of the more prominent interest for PC related 'fine work', and the high commitment of simulated lighting in current structures, identified with open space outline, security contemplations and problematic furniture design.

The amount of light gave alludes to the ideal measure of light required to perform efficiently a specified assignment, for example, perusing. Essentially, the nature of light likewise should be with the end goal that it is free from glare while having great shading rendering properties (Wright WD).

Becker (1991) watched that representatives are winding up plainly all the more requesting of their bosses, having higher desires for the physical condition at work than in past eras. Among their cravings is the longing for control over working environment highlights (Brill et al., 1984; Harris and Associates, 1987; Veitch and Gi¡ord, 1996). This control, regardless of whether as individual exchanging for lighting or indoor regulators, or operationalized as worker cooperation in working environment outline choices, is costly.

Both the focal sensory system and the neuroendocrine hormonal framework are impacted by the effective jolt of light (Ott 1982; Brody 1981; Wurtman 1975; Kotzsch 1988). Wurtman (A Summary of Light-Related Studies 1992) asserted that light has organic impacts vital to wellbeing and that some of these impacts could be measured in a lab.

Different wavelengths or scattered distributions of the effect of high light affect the human body. Most electrical light sources negatively affect humans, although fullrange fluorescent lighting is close to distinctive light (Hathaway et al., 1992).

We require wellspring of light in many fields of our lives which can be from the sun as sunshine or from fake source, for example, overhead light. The measures of lighting we have to finish our employments rely upon kind of occupations. Thus, when a man works a few exercises on indoor or during the evening, it is important to give him/her with some wellspring of brightening whether from characteristic light or from fake source (McCormick, 1992).

In 1983, Lockheed Martin creators effectively expanded cooperation among the designers by utilizing an open office format with coordinated daylighting in their workplaces in Sunnyvale, California (Romm and Browning 1994). This expansion helped support contract efficiency by 15%. Lockheed authorities trust that the higher profitability levels relating to daylighting helped them win a $1.5 billion barrier contract (Pierson 1995).

Pennsylvania Power and Light introduced high-productivity lights and counterbalances in the mid-1980s to lessen glare for drafting engineers. The impacts from the low-quality lights already utilized were causing glare, as well as spirit issues, eye strain, migraines, and expanded wiped out leave for workers (Lovins 1995). With enhanced lighting, efficiency for the drafting engineers expanded by 13.2% (Lovins 1995).

As per Dr. (Ott Biolight Systems, Inc. 1997), the body utilizes light as a supplement for metabolic procedures like water or nourishment. Characteristic light empowers basic organic capacities in the mind and is separated into hues that are imperative to our wellbeing. On a shady day or under poor lighting conditions, the failure to see the hues from light can influence our disposition and vitality level.

(Wijayatunga, P. D., Fernando, W. J. L. S., & Ranasinghe, S., 2003) summarized efficient use of energy in lighting needs to focus on the following selection of design aspects:

• Appropriate illumination levels;

• Efficient lamps and associated electrical control gear;

• Appropriately designed luminary systems; and

• Efficient levels of natural lighting.

2.5 Noise and Hearing

Several related investigations have suggested that people who have been continuously exposed to nonstop noise at levels of at least 85 dB have higher pulses than those not exposed to disturbances (Zawie, Zhang S, Celine S, Lance Resia, 1991) (Lang T, Foreword C, Jackin Mack, 1992).

Noise pollution affects both health and behavior. Unwanted sound (noise) can damage psychological health. Noise pollution can cause hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects (J.M.Field,1993).

Hearing loss leading to the inability to understand speech in everyday situations can have a severe social effect. It can also affect cognitive performance and decrease attention to tasks (Basner, M et al., 2014)

Most states have presented 85 dB as the defensive focus to be gone for (Embleton TFW, 1997). The upper activity estimation of 90 dB in the Noise Directive (86/188) was along these lines no longer worthy when measured against this objective or against the still present hazard at 90 dB, which much of the time is still more than 10%. It has also been discovered that the distinctive types of noise, such as discourse, music, and desk conflicts in general, in association with the quiet conditions, negatively affect diverse subjective outcomes, for example, memory impairment, appreciation, and editing (see Hongstow, 2005) schematic).

Clamor has additionally been widely considered in field contemplates. Ringing phones, ventilating, and office apparatus have all been proposed to cause unsettling influences in office conditions. Human discourse and its clarity is another regular diverting variable (Boyce, 1974; Pierrette, Parizet, Chevret, and Chatillon, 2014; Sundstrom et al., 1994).

ISO 1999 gives an approach to evaluate noise and hearing disability in populations exposed to relentless, irregular, or drive commotions all through running hours. Clamor presentation is described by methods for the equivalent sound degree over a 8-hr work day (LAeq,8h). relations are given (for presentation cases up to forty years) amongst LAeq,8h and commotion initiated hearing weakness at frequencies among 500 and 6,000 Hz. These relatives demonstrate that commotion caused hearing hindrance happens overwhelmingly inside the higher frequency of 3,000-6,000 Hz.

We will take a quick look at the basic principles and guidelines for noise reduction in the work environment which are linked to the universally accepted level, geometrically and clinically, and can be controlled and reduce their risk. In both of the far-reaching noise guidance (from 1986) and in the new guidance (from 2003), the noise relief takes a reasonable yet structure. Associated Standards:

- The noise must be kept to a base through specialized means and hierarchy (ISO 11690-1, -2, - 3) [3-5].
- Count: Turbulence relieves the source
- Selection of quiet machinery and work methodology
- Noise protection in the workroom (sound echoes, sound maximum limit, and loud noise retention).

Furthermore, the possibility that there are motives to fear hearing harm, regardless of the use of minimization measures, it should be limited to wearing hearing aids.

Chapter 3

METHODOLOGY AND DATA COLLECTION

3.1 Subjects

A total of twenty employees at EMU registrar office, fourteen females and six males were participated in this study. Their ages ranged between nineteen and fifty-seven years old.

3.2 Anthropometric Measurements

Anthropometry is the branch of the human sciences that deals with body measurements. Humans are variable. This variability is mostly related with ethnicity, gender and age (Jurgens et al., 1990). Anthropometric information are one of the basic factors in machines and apparatus design (Norris and Wilson, 1997). During the design phase, incorporating the information from anthropometry would yield more efficient designs, ones that are more user friendly, safer and enable higher performance and productivity. The lack of properly designed machines and equipment may reduce the work performance and increase the frequency of work-related injuries (Botha and Bridger, 1998).

Anthropometric estimations are along these lines a critical thought in outlining ergonomically fitting furniture for understudies, ergonomics and engineering where measurable information about the dispersion of body measurements in the populace are utilized to enhance items. The appropriation of body measurements would change when way of life (sustenance and physical) change from individual to individual. There require consistent refreshing of anthropometric information accumulations.

In this investigation, eleven anthropometry estimations were measured and particularly used as a piece of arranging seats and tables for understudies' registrar office furniture. Each and every anthropometric estimation were assembled using the understudies of Eastern Mediterranean University. In the midst of estimation each understudy person was asked to keep two unmistakable positions; sitting up right where knees and elbow bowed ninety degrees as in figure (3.1), and standing erect with the feet flat on the ground.

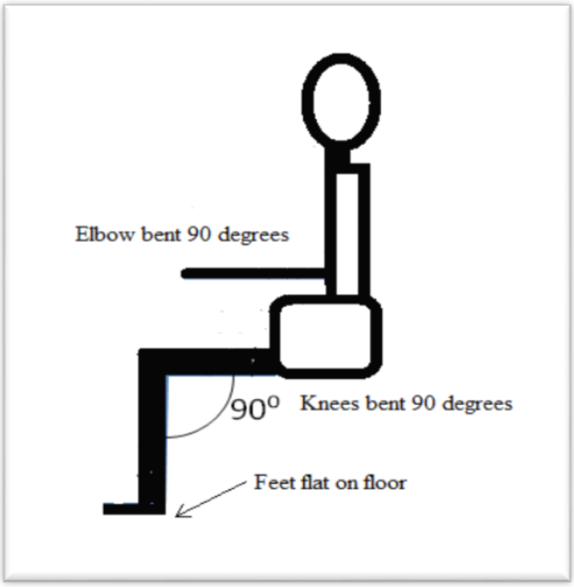


Figure 3.1: Sitting 90 Degrees of Knee and Feet Flat on Floor

The deliberate measurements were stature, shoulder height, shoulder elbow height, buttock to-popliteal length, popliteal stature, forearm hand length, hip width, elbow sitting stature, sitting height, eye sitting stature and overhead extend (figure 3.2) on next page, demonstrates every one of these measurements. On the normal, the above measurements took around 10 minutes to complete for every person or subject. The results of measurements for each participant.

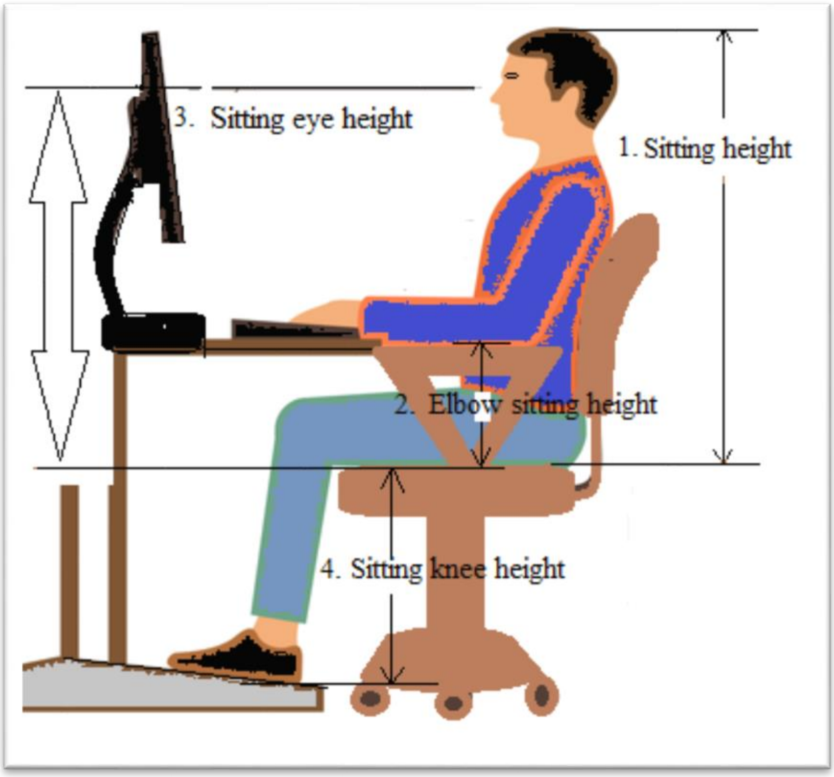


Figure 3.2: Eye Sitting Height

The main important measurements required are the sitting height, sitting elbow height, setting eye height, and the degree of sitting knee. These four measurements are shown in figure 3.1 and figure 3.2 above and they are defined as follows:

1. Sitting height: It is the vertical distance from the top of the head to the upper surface of the seat.
2. Elbow sitting height: It is the vertical separation from the seat surface to the underside of the elbow.
3. Sitting eye height: It is the vertical separation from the sitting surface to the inward canthus (corner) of the eye.

4. Sitting knee height: It is the vertical separation from the floor to the upper surface of the knee (normally measured to the quadriceps muscle instead of the kneecap).

The descriptions of human body dimensions that are recorded in this research are illustrated as follows in (figure 3.3) below.

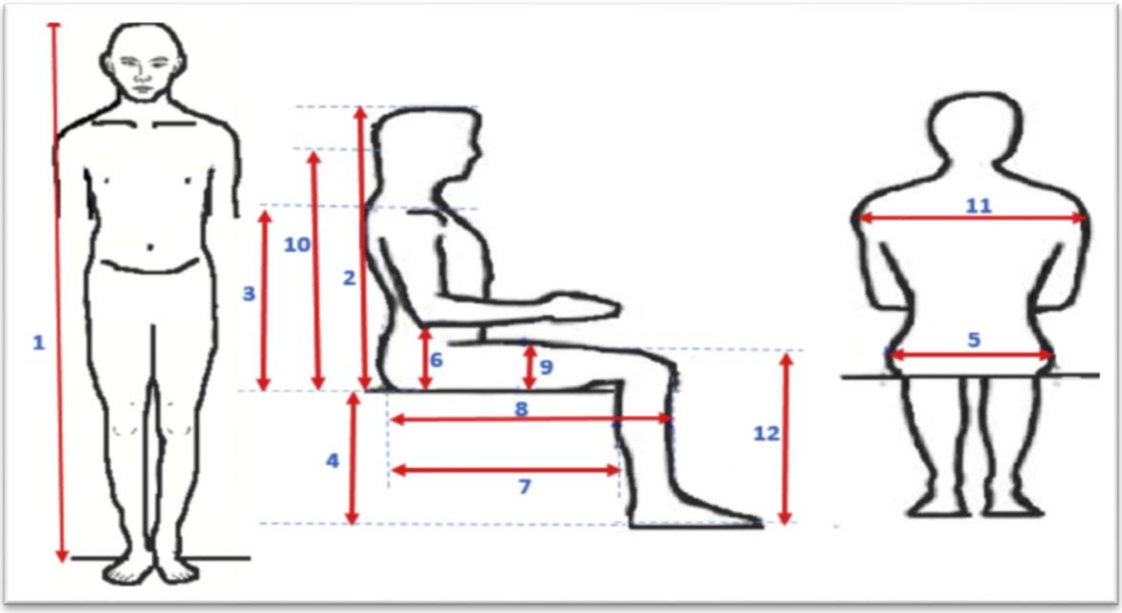


Figure 3.3: Anthropometric Measurements, (Taifa, I. W., & Desai, D. A. (2017)

Stature (body height) (1), sitting height (erect) (2), shoulder height, sitting (3), lower leg length (popliteal height) (4), hip breadth, sitting (5), elbow height, sitting (6), buttock-popliteal length (seat depth) (7), buttock-knee length (8), thigh clearance (9), Eye height, sitting (10), shoulder (bideltoid) breadth (11), knee height (12), and body mass (weight) (13).

3.3 Illumination

Objective estimation of light is essential in the plan and evaluation of premises. As the eye adjusts to light levels, naturally compensates for any adjustments in the illumination, and the target assessments to measure the light in the work area will most likely be tricky, and optical flux is what determines the lighting levels in place.

To clarify the study in the field of light, three basic elements must be explained and defined:

- Photometric Terms.
- Lighting Standards.
- Glare.

3.3.1 Photometric Terms

The estimation of light is known as photometry. The primary photometric units are luminance intensity, luminance flux, luminance, illuminance, and reflectance. The SI unit of luminance intensity is the candela (cd), and the definitions are as follows in table 3.1.

Table 3.1: Main Photometric Terms

Luminance intensity (candela) cd	The power of a source or illuminated surface to emit light
Luminance flux (lumen)	The rate of flow of luminous energy
Luminance (cd/m^2)	The light emitted by a surface
Illuminance (lux)	The amount of light falling on a surface
Reflectance (%) Factor (0-1)	The ratio of the luminance and illuminance at a surface

The luminance of an object depends on the light it emits or reflects toward the eye. It corresponds roughly to brightness, although brightness perception depends on other factors, such as contrast. The percentage of the incident light which is reflected by a surface depends on the reflectance of the material. Reflectance is defined in table 3.1

as the ratio of luminance to illuminance. White paper has a reflectance of about 95 percent; newspaper, about 55 percent; plain wood about 45 percent. Matte black paper has reflectance of about 5 percent. More formally, reflectance is given by:

Reflectance = $\frac{lumi \times \pi}{illumi}$

Where, lumi: is luminance (cd/m^2) and illumi: is illuminance (lux).

3.3.2 lighting standards

Under the Health and Safety at Work Act of 1974, a business has an obligation to guarantee the wellbeing and security of representatives. The Act incorporates an obligation to give lighting to guarantee that work can be attempted securely. It likewise expresses that representatives wellbeing or vision must not be risked. Control no.8 of the Workplace Regulations Act 1992 states that businesses must guarantee that:

- Every working environment has appropriate and adequate lighting.
- This ought to be common light, so far as is sensibly practicable.

Much effort has been applied over many years to the drafting of standards for the illumination of workplaces. Standards differ from country to county. Table 3.2 present recommended illuminances and (table B.2 in Appendix B page 90) show more illuminance levels for various work situations.

Table 3.2: Illuminance Levels, Activity, and Area

Illuminance (Lux)	Activity	Area
300	Visual tasks moderately easy	Libraries, sports halls, lecture theaters.
500	Visual tasks moderately difficult	General offices, kitchens, laboratories, retail shops.
750	Visual tasks difficult	Drawing offices, meat inspection, chain stores.

3.3.3 Glare

Glare happens when there is an awkwardness of surface or question luminances in the visual field, the brighter sources surpassing the level to which the eye is adjusted. Wellsprings of glare incorporate the sun, brilliant or stripped lights, or impression of glossy articles. Additionally, inconvenience glare may happen in workplaces, glare might be immediate or roundabout; it might be transmitted by a source or reflected of a protest.

3.4 Noise and Sound Level Measurements

A healthy young man can hear sounds in the range of 16 to 20,000 Hz. Noise is usually characterized as unwanted sound or sounds, causing worry and discomfort. The sound can be measured neutrally, but the noise is a subjective phenomenon.

The amplitude of sound is objectively evaluated by measuring the sound pressure level (SPL). The ranges of SPLs to which the human ear is sensitive is so wide (0.00002 N/m^2 to 20 N/m^2) that linear scaling would present a problem. For this reason, a logarithmic scale – the decibel scale – is used to express the intensity of sound. The decibel (dBA) is a dimensionless unit related to the logarithm of the ratio of the measured sound pressure level to a reference level. Commercial sound-level meters' measure and display a root mean square (rms) SPL, Lp,

$Lp = 20 \log_{10} (p/pr)$ dBA

Where Lp = sound pressure level, dBA

P = sound pressure, N/m^2

Pr = reference sound pressure level (0.00002 N/m^2)

3.5 The Equipment and Apparatus Used in this Study

1. Anthropometric ruler

2. Lux meter
3. Sound level meter
4. Maico audiometer
5. Optec vision tester

3.6 Data Collection

The data and information required for the study were collected at different stages and levels, as follows:

3.6.1 A questionnaire

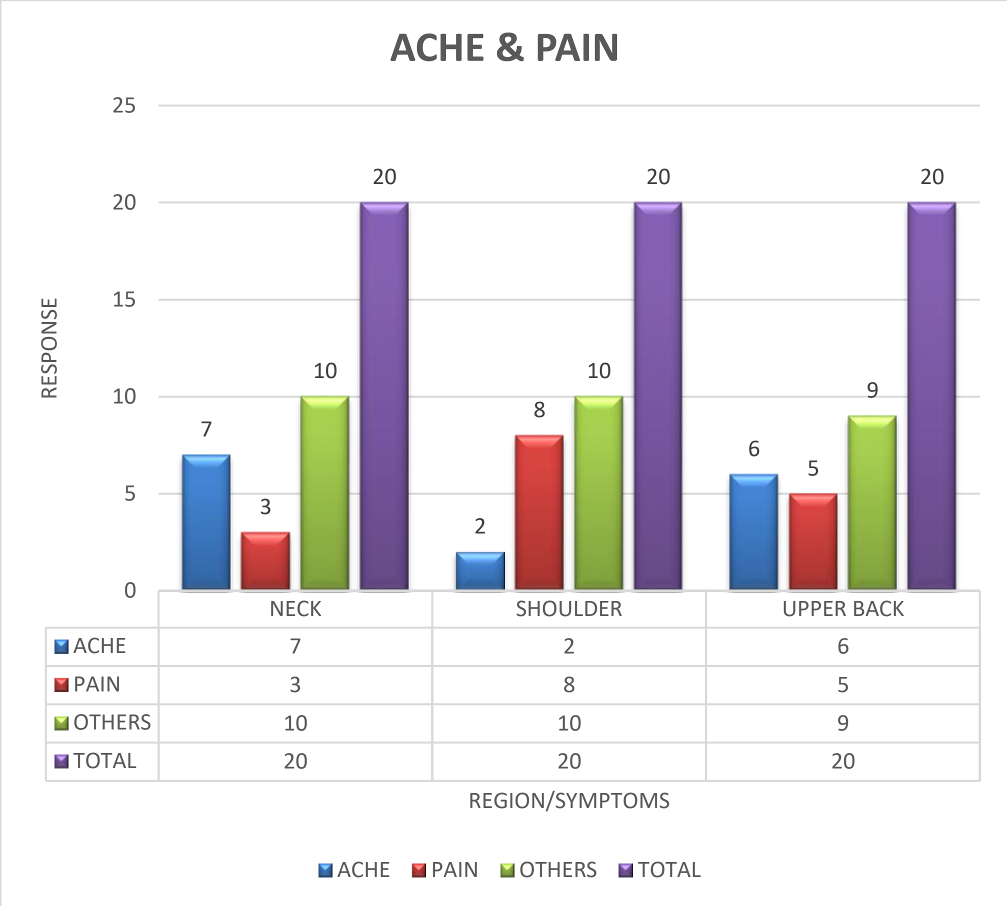
The data was collected and organized in a systematic and sequential manner. At the beginning, a questionnaire was issued and approved by Ethics Committee of EMU as it shown in (Appendix D, page 109), it was distributed to the staff at the registration department of the Eastern Mediterranean University, which includes the participant's personal information such as gender, age, height, weight, working hours, daily working hours and computer usage.

The questionnaire also dealt with the health problems experienced by the employee and inquiring about any symptoms, aches, pains, etc. in different parts of the body and muscles. In addition to the above, the survey was conducted on the surrounding physical factors such as light, visibility, noise, hearing level, daily rest time, exercise and the extent of exercise by the employees. Twenty person answered the questionnaire; the majority of them is female.

The results of the questionnaire showed that the employees need more comfortable seats as seem as they have ache and pain in neck, shoulders, and upperback. Table 3.3

below shows very important results to continue our methodology through anthropometric measurements and design.

Table 3.3: Questionnaire Results at EMU Registrar Office



3.6.2 Anthropometric measurements

The anthropometric measurements required measuring instruments such as the anthropometric ruler. Each participant's gender, and age were taken. The eleven measurements were then made regularly for all twenty staff members. The measurements included height, shoulder height, shoulder elbow height, buttock popliteal height, popliteal height, knee height, forearm hand length, hip width, elbow sitting height, sitting height and sitting eye height. Data were recorded on separate forms as shown in the table below.

Table 3.4: Sample Form to Record Measurement of Employees

Table number	
Gender	
Age	
Height (cm)	
Shoulder height (cm)	
Shoulder elbow height (cm)	
Buttock popliteal height (cm)	
Popliteal height (cm)	
Knee height (cm)	
Forearm hand length (cm)	
Hip width (cm)	
Elbow sitting height (cm)	
Sitting height (cm)	
Sitting eye height (cm)	

3.6.3 Optical Vision Tester Measurements

We have been worked on the (OPTICAL INDUSTRIAL VISION TESTER) system in order to obtain the results of accurate examinations for yes functions of employees, which amounted to 12 examinations. To achieve this purpose, a model was drawn up and the subjects, number and age were taken. The 12 tests included several targets to examine the eyes together or individually for each eye and at long and close distances, in addition to examining the depth of vision and color discrimination. Only nineteen employees participated in the test, and (table 3.5) next page shows 12 targets were used during the vision tests, and these records in table represent normal results. Where the letters (T, B, R, and L) are the top, bottom, right, and left position of the broken ring in each figure of the acuity tests. Additionally, the acuity level was measured according to the correct answers of the employee, for example if the subject answers on 10 questions correctly, he/she is normal. But if the subject answers less than 10 or more than, he/she has no clarity of vision.

Table 3.5: Stereo Optical Industrial Vision Tester Record

TEST #	TARGET	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2	BOTH EYES	T	R	R	L	T	B	L	R	L	B	R	B	T	R
3	RIGHT EYE	T	L	T	T	B	B	L	B	R	T	R	L	B	R
4	LEFT EYE	L	R	L	B	R	T	T	B	R	T	B	R	T	L
	ACUITY LEVEL	$\frac{20}{200}$	$\frac{20}{100}$	$\frac{20}{70}$	$\frac{20}{50}$	$\frac{20}{40}$	$\frac{20}{35}$	$\frac{20}{30}$	$\frac{20}{25}$	$\frac{20}{22}$	$\frac{20}{20}$	$\frac{20}{18}$	$\frac{20}{17}$	$\frac{20}{15}$	$\frac{20}{13}$
5	STEREO DEPTH	1 B	2 L	3 B	4 T	5 T	6 L	7 R	8 L	9 R					
6	COLOR	**A 12**	**B 5**	**C 26**	**D 6**	**E 16**	**F**								
7	VERTICAL	1	2	3	4	5	6	7							
8	LATERAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14
TEST #	**TARGET**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
9	BOTH EYES	R	L	T	R	B	R	T	L	T	L	B	R	B	L
10	RIGHT EYE	T	B	T	B	R	T	R	L	B	L	R	R	L	T
11	LEFT EYE	B	L	B	R	T	L	T	B	R	R	L	R	T	L
12	LATERAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14

3.6.4 Illumination Measurements

Staff offices are located on the ground floor of the U- shape Registration Section, and there is an outside closed-down separator and a transparent glass wall fixture as a boundary between the employee and the student reviewers. The lighting was distributed all over the place. The lighting level was measured by a device and 3 readings were recorded on the right and left of the office and in the middle. The tests were conducted in 33 places within the registration department.

3.6.5 Audiometer Tests

In addition to studying the impact of noise on hearing, air conduction tests were conducted for 19 employees. Each ear was tested independently of the other. The measurement results are transferred directly to the audiogram. The test was conducted in two stages for each participant, the lines with red circles represent the right ear and the lines with blue Xs represent the left ear. The following figure illustrates the above.

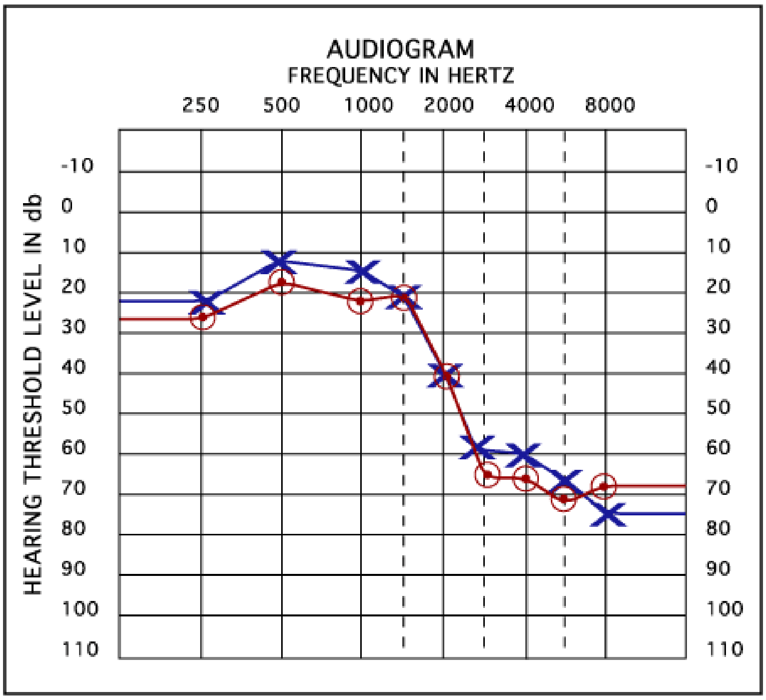


Figure 3.4: Audiogram and Air Conduction Test

3.6.6 Sound Level Measurements

To ensure accuracy in measuring the volume and noise in the registrar office, I performed the operation three times per day and at different periods. The first period is between 10 AM to 11 AM. The second period is between 12 PM to 1 PM. The third period is between 2 PM to 3 PM. Over three different days records were measured (Thursday, Friday and Monday) at 32 different locations. A sound level meter from

Ergonomic Laboratory of Industrial Engineering Department was used during the measurements process and data collection.

The collected data were analyzed in chapter four and illustrated in Appendices A (Anthropometric measurements), B (Illumination and vision measurements), C (Noise and Air conduction measurements), and D (Questionnaire)

Chapter 4

EXPERIMENTAL DESIGN AND ANALYSIS

4.1 Experiment Design

Experimental design is a powerful basis in scientific research and is an applied statistical procedure used to improve processes. The variables of the most influential process are studied and the variables with the insignificant effect are examined.

In this research we can look at the experience to compare the two conditions that usually are named treatments. For example, the popliteal height for the employee is an essential feature of the seat height design. Subsequently, the designer is interested in comparing the height of the male and female. In this study we will compare between the match of treatment (male and female) for all anthropometric dimensions of employees. The majority of comparison will be for height, shoulder height, shoulder elbow height, buttock popliteal length, popliteal height, knee height, and hip width that are utilized as a part of workstation design.

The experiment is designed and implemented as follows. First, 20 employees were selected from the registration department, followed by a comprehensive questionnaire distributed to all of them, as well as an anthropometric test to measure the employee's body dimensions. Topics were randomly selected for measurement.

The meanand standard deviation of every single anthropometric estimation, male and female, was computed.

4.2 The Normality Assumption

Before applying statistical method that supposes normality, it is necessary to perform normality test on anthropometric body dimensions. The normality assumptions are easy to check by using a normal probability plot. Generally, we can perform it quickly by Minitab15. Minitab 16 gives a p-value so; we can compare this value with our assumed type error alpha (which is equal to 0.05).

The null hypothesis expresses that, the anthropometric data of male and female staff follows a normal distribution. We will reject the null hypothesis when the p-value is less than alpha level. As can be seen from Minitab output, the p-value is larger than 0.05, this implies that we cannot reject the null hypothesis and it is concluded the data distribution is normal. Moreover, as illustrated in figure (A.1 to A11, pages 82 to 87) in Appendix A, and all observations are close to the straight line on the graphs. Henceforth, the null hypothesis about normality is verified.

4.3 Percentile Calculations

The formula below is used to compare percentiles of a normal distribution.

$$K^{th} \text{ percentile} = \mu \pm z\, \sigma \qquad (4\text{-}1)$$

Where μ is the mean of anthropometric dimensions which are (height, shoulder height, shoulder elbow height, buttock-to-popliteal length, popliteal height, knee height, forearm hand length, hip width, elbow sitting height, sitting height and eye sitting height). Also, σ is the standard deviation of each measurement and z is the value from the standard normal distribution for the wanted percentile. If we take any human body dimension such as elbow sitting height, we will find the 5^{th} and 95^{th} percentiles as follows:

5^{th} $$P_{\text{sitting height}} = \mu_{\text{sitting height}} - 1.65 * \sigma_{\text{sitting height}}$$

95^{th} $P_{sitting\ height} = \mu_{sitting\ height} + 1.65 * \sigma_{sitting\ height}$

The average (μ) and the standard deviation (σ) of a human body dimension can be taken from table (4.1).

Table 4.1: Min, Max, Mean, and Std. Deviation

	Minimum	Maximum	Mean	Std. Deviation
Height	154	184	167.01	7.25
Shoulder H	47	63.2	56.83	7.20
Shoulder Elbow H	27	43	34.50	4.95
Buttock Popliteal H	36	51	44.33	4.59
Popliteal H	44	56	51.39	3.82
Knee height	40	55	50.55	3.82
ForearmHand Length	31	47	41.33	4.33
Hip Width	27	53	36.70	5.54
Elbow Sitting Height	17	26	20.77	2.31
Sitting Height	64	87	78.26	6.681
Sitting Eye Height	53	78	67.66	7.464

Lighting needs to be adjusted within the appropriate health and environmental standards, where lack of lighting is a problem and the physical hazards that surround the staff in the workplace.

Similarly, the sound pressure level (SPL) was measured at 32 different locations at three regular times per day and the process was repeated for three days.

Chapter 5

RESULTS AND DISCUSSION

5.1 Registrar Office Furniture

The registrar office at EMU contains suitable places and consists of 32 positions which have tables, chairs, and computers per each position. All chairs (seats) are the same shape and design. Their dimensions are as shown in table 5.1 below.

Table 5.1: Equipment Dimensions

Dimensions	Measurement (cm)
Seat height (Minimum)	38
Seat height (Maximum)	49
Seat depth	44
Seat width	45
Max height of backrest	42
Armrests height	20
Desk height	78.5

5.2 Anthropometric measurements and mismatch

The measurements of the employees' bodies are analyzed by SPSS 22 and Excel 2007. Basic descriptive statistics were used to compute minimum and maximum values, mean and standard deviation for anthropometric data.

We can compute the 5th and 95th percentile by utilizing formula (4-1). In the event that we take any measurement from table (A.1a) and table (A.1b) in Appendix A page 70 and 71 respectively, for example, the average for shoulder elbow height for male and female are 33.61 cm and 36.58 cm respectively, with standard deviation of 4.869 cm and 4.922 cm individually.

Let: mean = μ and standard deviation = σ, then the percentiles of shoulder elbow height (SHEH) from table 5.4 above are:

5^{th} percentile (male) = $\mu - 1.65\,\sigma = 36.58 - (1.65*4.922) = 28.46$ cm.

5^{th} percentile (female) = $\mu - 1.65\,\sigma = 33.61 - (1.65*4.87) = 25.58$ cm.

95^{th} percentile (male) = $\mu + 1.65\,\sigma = 36.58 + (1.65*4.922) = 44.70$ cm.

95^{th} percentile (male) = $\mu + 1.65\,\sigma = 33.61 + (1.65*4.87) = 41.64$ cm.

The difference range of 5^{th} percentile between male and female is

$$= 28.46 - 25.58 = 2.88 \text{ cm.}$$

Also, it is 3.06 cm for the difference range of 95^{th} percentile.

Based on the differences between the dimensions of the employees' bodies on the one hand, and between those dimensions and the furniture used to sit and work on the other hand, we made calculations to measure the extent of the mismatch between each part of the body and the measurements of seat and table. So we calculated the mismatch between popliteal height (PH), buttock popliteal length (BPL) and seat depth (SD), hip width (HW) and seat width (SW), elbow setting height (EHS) and desk height (DH), shoulder height (SHH) and backrest height (BRH), and knee height (KH).

These measurements were very important to design comfortable seat and convenient table as it shown in figure 5.1 next page.

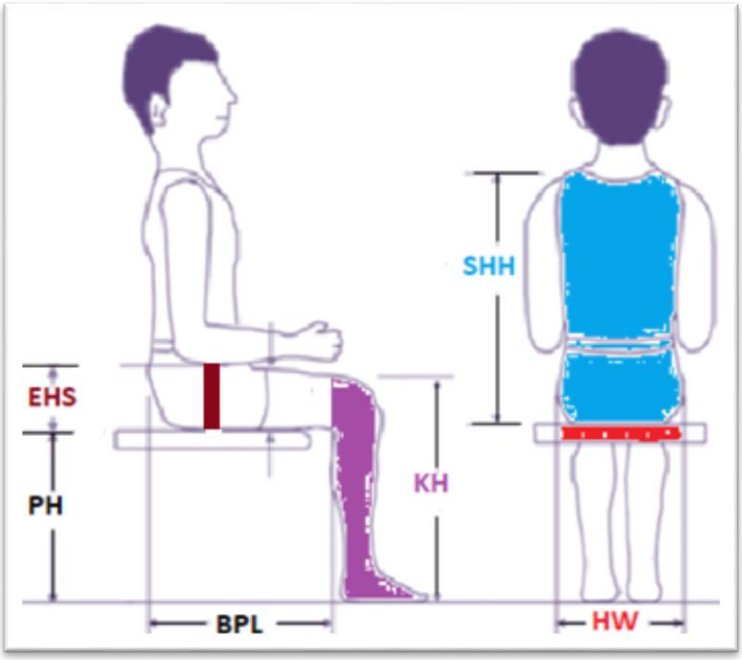


Figure 5.1: the six body measurements for seat and table design

5.3 Combination of Statistics and Optimization

The aim is to determine the specific design for seats and tables.

- Seat design: it is very important source of comfort to the employee, because they spend more than seven hours sitting on the chairs. Therefore, it is essential to choose a suitable designed chair to enable the employees work efficiently, decrease the stress on their musculoskeletal. The tables from (A.2 to A.7) on pages (72 to 79) in appendix A shows mismatch between anthropometric variables for male and female employees. So that the seat and table design were different between male and female.

5.3.1 Popliteal Height and Seat Height

(Gouvali, 2006) Presented the match model as the following:

$$PH \cos 30° < SH < PH \cos 5° \quad (5\text{-}1)$$

At the point where PH = Popliteal Height and SH = Seat Height

In this way, the mismatch happens when the current seat height is under cos30° or more than cos5° of popliteal height.

SH > 0.866PH & SH < 0.996PH

Then, $\frac{SH}{0.996} \leq PH \leq \frac{SH}{0.866}$

According to the hypothesis of our design that $\mu_{female} \neq \mu_{male.}$ The design for female and male will be different.

- **Popliteal height and seat height for female**

The population whose body dimension matches with current seat height of (47cm) is:

$$\frac{48}{0.996} \leq PH \leq \frac{48}{0.866}$$

$48.19 \leq PH \leq 55.43$

When we refer to table A.1a in Appendix A, we can see the mean value of popliteal height for 14 female employees is 51.357cm and the standard deviation is 3.712.

Proportion match of population P= $\frac{48.19 - 51.357}{3.712} \leq \frac{PH - \mu}{\sigma} \leq \frac{55.43 - 51.357}{3.712}$

From table A.2 in Appendix A we find P= $(-0.85 \leq Z \leq 1.1)$

= P2-P1= 0.86-0.20= 0.667 (P2: upper bound, P1: lower bound).

As a result, the current seat height is fitting for 66.7% of female. To optimize this percentage, we will calculate this proportion for different seat height, and the proportion of employees match are seen in the table A.2 in Appendix A, page 72, and the seat height is 47 cm. To reduce the mismatch for optimal design we can follow the adjustable method. Referring to table (A.1a) in Appendix A, on page 69 we find the adjustable seat height. Then,

Minimum height = 5th percentile of popliteal height of female = 45.24 cm

Maximum height = 95th percentile of PH of female = 57.48 cm.

The mismatch for female between popliteal height and seat height is as follows in table 5.2 below.

Table 5.2: The Mismatch Between Popliteal Height and Seat Height For Female

Method of Design	Lower Bound (cm)	Upper Bound (cm)	Number of Mismatch	Mismatch Ratio
Optimizing method	48.19	55.43	5	5/14 = 35%
Adjustable method	45.24	57.48	1	1/14 = 7 %

- **Popliteal Height and Seat Height for Male**

When we refer to table A.1b in Appendix A, page 71 we can see the mean value of popliteal height for 6 male employees is 51.45 cm and the standard deviation is 4.43

Proportion match of population P = $\frac{48.19-51.45}{4.43} \leq \frac{PH-\mu}{\sigma} \leq \frac{55.43-51.45}{4.43}$

From table A.2 in Appendix A we find P = $(-0.74 \leq Z \leq 0.90)$

= P2-P1= 0.815 – 0.231 = 0.584 (P2: upper bound, P1: lower bound)

As a result, the current seat height is fitting for 58 % of male.

To optimize this percentage, the proportion for different seat height will be caculated, and the proportion of employees match are seen in the table A.3 in Appendix A, page 73, and the seat height is 48 cm. To reduce the mismatch for optimal design we can follow the adjustable method. Referring to table (A.1b) in Appendix A, on page 71 we find the adjustable seat height. Then,

Minimum height = 5^{th} percentile of popliteal height of male = 44.14 cm

Maximum height = 95^{th} percentile of PH of male = 58.76 cm.

The mismatch for male between popliteal height and seat height is as follows in table 5.3 below.

Table 5.3: The Mismatch Between Popliteal Height and Seat Height For Male

Method of Design	Lower Bound (cm)	Upper Bound (cm)	Number of Mismatch	Mismatch Ratio
Optimizing method	48.19	55.43	3	3/6 = 50 %
Adjustable method	44.14	58.76	0	0 %

5.3.2 Buttock-to-Popliteal Length (BPL) and Seat Depth (SD)

Most planners suggested that, seat depth ought to be intended for the 10th of the popliteal buttock length circulation. (Poulakakis and Marmaras, 1998) recommended that depth ought to be not less than 5cm shorter than popliteal butt cheek length. (Parcells, 1999) determined the mismatch when the seat depth was ≥ 95% or ≤ 80% of buttock to-popliteal length.

$$0.80\ BP \le SD \le 0.95\ BP \qquad (5\text{-}2)$$

Where BP is buttock to-popliteal length, and SD is the seat depth.

Then, $\frac{SD}{0.95} \le BP \le \frac{SD}{0.80}$

- **BPL and SD for Female**

From table 5.1 the seat depth (SD) = 44 cm, and from equation (5-2) BP will be as following

$$\frac{44}{0.95} \le BPL \le \frac{44}{0.80}$$

$$46.3 \le BPL \le 55$$

This result shows that the lower bound of buttok popliteal length is 46.3 cm and the upper bound is 55 cm, so to fit and adapt with the present seat depth (44 cm). but the mismatch of female employees between buttock popliteal length and seat depth very high and equal 64% as it was shown in table A.1a in Appendix A, page 70.

The optimizing method shows highest ratio of mismatch, but if we follow the adjustable method the mismatch will decrease from 64% to 36%, and the proposed design for seat depth is to get the 0.95 of 5th percentile of female buttock popliteal length. Then, the seat depth for female = 0.95 × 35.91 = 34.11 cm. The mismatch between BPL and SD illustrated in Table 5.4

Table 5.4: The Mismatch Between BPL and Seat Depth For Female

Method of Design	Lower Bound (cm)	Upper Bound (cm)	Number of Mismatch	Mismatch Ratio
Optimizing method	46.3	55	9	64 %
0.95 of 5th percentile	34.11	34.11	0	0 %

- **BPL and SD for Male**

The seat depth at the 5th percentile of male popliteal buttock length is 95% × BPL = 0.95 × 39.16 = 37.2 cm as it is shown in table 5.5 below.

Table 5.5: The Mismatch Between BPL and Seat Depth For Male

Method of Design	Lower Bound (cm)	Upper Bound (cm)	Number of Mismatch	Mismatch Ratio
Optimizing method	46.3	55	3	3/6 = 50 %
0.95 of 5th percentile	37.2	37.2	0	0 %

5.3.3 Hip Width (HW) and Seat Width (SW)

The seat width must be large enough to provide accommodation for users with the largest hip. To decrease the mismatch between hip width and seat width; the seat width should be designed at 90th percentile of hip width distribution or the largest hip (Gouvali, 2006) proposed a modified equation (5-3).

$$1.1HW \le SW \le 1.3HW \qquad (5\text{-}3)$$

We can see from equation (5.3) that the mismatch occurs out of these controls when the seat width is less than 1.1 or greater than 1.3 of hip widths.

- **Hip Width and Seat Width for Female**

We know from table A.1a in Appendix A that μ = 39.914 cm and σ = 4.402 for hip width, and the seat width = 45 cm (table 5.1), so we can find the proportion of matching the seat width (SW) as follows

$$P = \frac{\frac{SW}{1.3} - \mu}{\sigma} \le \frac{PH - \mu}{\sigma} \le \frac{\frac{SW}{1.1} - \mu}{\sigma}$$

P = $(-0.38 \le Z \le 0.77)$ = 0.78 – 0.35 = 0.43

By referring to the tables A.5a, A.5b, and A5.c in Appendix A pages (75 to 77) and figure A.12 in Appendix A (page 87) we find the maximum percentage of matching is 43% when seat width is 45 cm. On the other hand, if we design at the maximum value of hip width (52.8 cm), we will decrease the mismatch between seat width and hip width from 57% to 0% as it is illustrated in table 5.6

Table 5.6: Mismatch Between Seat Width & Hip Width for Female

Method of Design	Seat width (cm)	Mismatch ratio
Optimizing method	45	57%
Extreme method	52.8	0 %

- **Hip Width and Seat Width for Male**

From equation 5-3 the ratio of matching between hip width and seat width for male was 42% as it was illustrated in table A.5c in Appendix A, page 77. We know that the maximum value of hip width for male is 38.4 cm, and if we design by the extreme method, the seat width will be at least 38.4 cm and the mismatch between HW and SW will eliminate. Table 5.7 below, shows that.

Table 5.7: Mismatch Between Seat Width & Hip Width for Male

Method of Design	Seat width (cm)	Mismatch ratio
Optimizing method	45	58%
Extreme method	38.4	0 %

5.3.4 Shoulder Height (SDH) and Backrest Height (BH)

The backrest height suggested by (Gouvali, 2006) as keeping the backrest lesser than the shoulder height, or the upper edge of shoulder (60-80% of shoulder height).

$$0.6\ SDH \leq BH \leq 0.8\ SDH \qquad (5\text{-}4)$$

The mismatch happens when the backrest is more than 0.8 of shoulder height and less than 0.6 of shoulder height.

From equation (5-4) above, the shoulder height can be found from equation (5-4)

$$\frac{BH}{0.8} \leq SDH \leq \frac{BH}{0.6}$$

- **Shoulder Height an Backrest Height for Female**

Referring to table A.6a on page 78, the maximum proportion of match population is 67% at backrest height equal 40 cm. Table 5.6 below shows the mismatch between shoulder height and backrest height. By the adjustable method the mismatch was illuminated. The minimum and maximum backrest height will be

$33.77 \leq BH_{female} \leq 45$ cm.

The table 5.8 below shows the difference between optimizing method and adjustable method of mismatch ratio.

Table 5.8: Mismatch Between Shoulder Height & Backrest Height for Female

Method of Design	Backrest Height (cm)	Mismatch ratio
Optimizing method	40	33 %
Adjustable method	33.77 to 45	0 %

- **Shoulder Height and Backrest Height for Male**

From equation 5-4 the backrest height for male will be 39 cm and matching 100% as it is shown in table A.6c page 79. Similarly, the backrest between 34.86 and 46.48 will confirm the shoulder height of male employees, the lower and upper bound of backrest height for male employees are:

$34.86 \leq BH_{male} \leq 46.48$ cm

The table 5.9 below shows the mismatch ratio for male by optimizing and adjustable methods.

Table 5.9: Mismatch Between Shoulder Height & Backrest Height for Male

Method of Design	Backrest Height (cm)	Mismatch ratio
Optimizing method	40	33 %
Adjustable method	33.77 to 45	0 %

5.3.5 Elbow Sitting Height (EH) and Desk Height (DH)

Elbow sitting height is the essential dimension to determine the table height so that, the most researchers considered it as the major criterion for desk height. Therefore, the lowest table height we will get it when the shoulders are not in flexion or abduction, but when the shoulder are at 25° flexion and 20° abduction the table height will be at the maximum therefore, the criteria of mismatch as in the equation (5-5).

$$EH + \cos 30° \, PH < TH < \cos 5° PH + 0.852EH + 0.148SDH \qquad (5\text{-}5)$$

- **Table Height Design for Female**

Table Height female = Popliteal height female + Sitting elbow height female

Minimum Table Height $_{female}$ = 43.6 +16.7 = 60.3 cm

Maximum Table Height $_{female}$ = 56 + 25.7 = 81.7 cm

The proportion of match population at current table height = $1-P_2 = 0$, and we can see that in table (A.7a, page 80) in Appendix A. At the same time the optimal desk height is 62.5 cm and the proportion of match is 100% when ES is greater than 20.93 cm. Table 5.10 below shows the mismatch between table height and elbow sitting Height.

Table 5.10: Mismatch Between Table Height & Elbow Sitting Height for Female

Method of Design	Table Height (cm)	Mismatch ratio
Optimizing method	62.5	0 %
Adjustable method	60.3 to 81.7	0 %

- **Table Height Design for Male**

Table Height $_{Male}$ = Popliteal height $_{male}$ + Sitting elbow height $_{male}$

Minimum Table Height $_{Male}$ = 45.2 +18.7 = 63.9 cm

Maximum Table Height $_{Male}$ = 55.5 + 25.5 = 81 cm

The proportion of match population at current table height = 1-P2 = 0, and we can see that in table (A.7b, page 81) in Appendix A. At the same time the optimal desk height is 61.5 cm and the proportion of match is 100% when ES is greater than 20.93 cm.

Table 5.11: Mismatch Between Table Height & Elbow Sitting Height for Male

Method of Design	Table Height (cm)	Mismatch ratio
Optimizing method	61.5	0 %
Adjustable method	63.9 to 81.7	0 %

5.3.6 Underneath Table Height (UT)

Table clearance is shown to be the space between the knees and the underneath surface of the work area. (Parcells, 1999) suggested the table height ought to be no less than 20 mm. This space enables the knees to be more agreeable under the table.

$$UT \geq 20 + \text{Knee Height} \quad (5\text{-}8)$$

UT = 20 mm + maximum knee height

- **Underneath Table Height for Female**

For female employees, the UT = 2 + 54.4 = 56.4 cm

Where this height is less than the lower height of table that designed for female (60.3 cm). it is a convenience for sitting and working.

- **Underneath Table Height for Male**

For male employees, the UT $\geq$ 2 + 55.4 = 57.4 cm. The minimum height of the desk for male employees is 63.9 cm. The maximum knee height is 55.4 cm $\leq$ UT -2. Similarly to the same criteria that was used before the clearance between knee and minimum height of table is very useful and necessary for convenience.

Table 5.12: Mismatch Between Anthropometric Measurements and Registrar Office Furniture For the Proposed Ergonomic Design Methods

Item	Method of Design	Male	Female	Mismatch		
				M	F	M&F
Seat Height (S.H) cm	Adjustable	44.14 – 58.76	45.24 – 57.48	0	7	5
Seat Depth (S.D) cm	0.95 of 5th percentile	37.2	34.11	0	0	0
Seat Width (S.W) cm	Extreme	38.4	52.8	0	0	0
Table Height (T.H) cm	Adjustable	63.9 - 81	60.3 – 81.7	0	0	0
Backrest Height (B.H) cm	adjustable	34.86 – 46.48	33.77 - 45	0	0	0
Underneath Table (U.T) cm	Extreme	57	56	0	0	0

The description of all anthropometric body dimensions were defined by ISO 7250 as it shown in table 5.13 below, and (figure 5.4) in next page shows all these dimensions.

The target of this investigation is to assess the plan of EMU registrar office by utilizing the mismatch proportion. In this way, we proposed a method to plan the tables and seats of workstations. This outline depends on the ideal extent of design. From that point onward, the outlines will be analyzed and the best workstation model will be chosen.

Table 5.13: The Anthropometric Body Description and Definitions

Description	Definition
Stature	the vertical distance taken from the floor to the highest point of the head when the student stand erect and looking straight ahead
Sitting height	the vertical distance from the top of the head to the upper surface of the seat
Elbow sitting height	the vertical separation from the seat surface to the underside of the elbow.
Sitting eye height	the vertical separation from the sitting surface to the inward canthus (corner) of the eye
Sitting knee height	the vertical separation from the floor to the upper surface of the knee (normally measured to the quadriceps muscle instead of the kneecap).
Shoulder height	the vertical distance from the top of the shoulder at the acromion to the subject's sitting plane or seat pan.
Shoulder elbow length	the difference between the elbow sitting height and shoulder height.
Buttock-to-popliteal length	the horizontal distance from the posterior surface of the buttock to the posterior surface of the knee or popliteal space
Hip width	the maximum horizontal distance across the hips in the sitting surface.
Popliteal height	the vertical dimension, with 90° knee flexion, from the foot resting surface to the posterior surface of the knee or popliteal surface.
Knee height	the vertical distance, with 90° knee flexion from the foot surface to the top of the kneecap.
Forearm hand	the horizontal distance from the elbow to fingertip

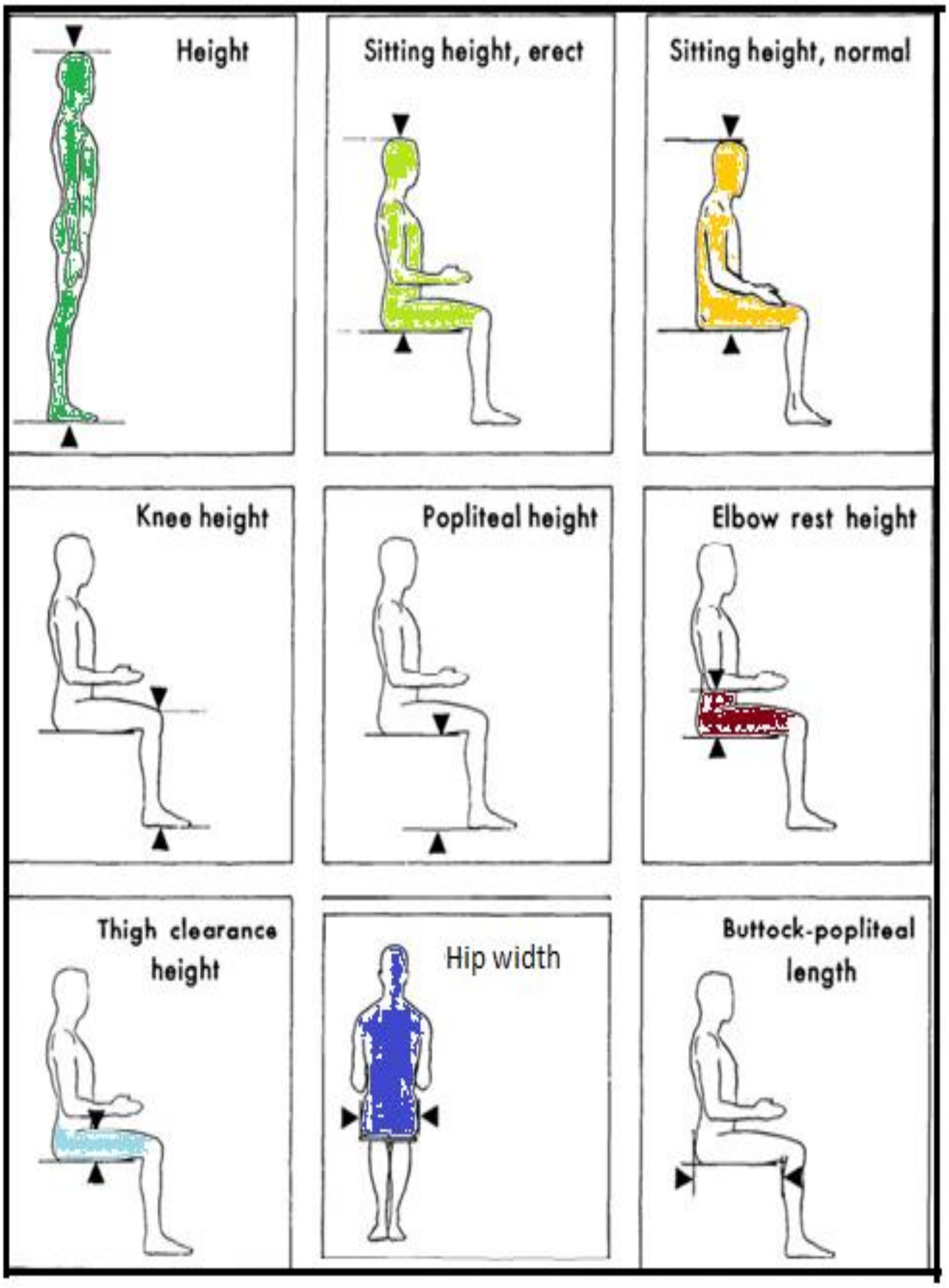


Figure 5.2: Anthropometric body dimension

Figure 5.2 above describes all of the dimensions that were needed in anthropometric design for seats and desks.

5.4 Illumination measurements

The human factors and occupational health determined safety procedures to help the employees be in control of the limits of safety and health controls, which is also a preventive measures that control the factors and make them under control.

Lighting is one of the most important physical elements in the work environment surrounding employees, which affect their behavior and their response to the performance of their daily work. Accordingly, the light levels in the registration department at Eastern Mediterranean University were measured and examined the eyes of the staff as part of the methodology of optical vision test in chapter 3.

The survey and measurement have produced useful, accurate and reliable results for positive and effective design to create a safe and risk-free work environment.

The measurements of the illumination are listed in table 5.14 next page. Analysis of data was done by SPSS 22, Minitab 16 and Excel 2007. Basic descriptive statistics were used to compute minimum and maximum values, mean and standard deviation for illumination. Also, the results of vision test were done by Optec Vision Tester, and the results were saved and analyzed by Excel 2007 and SPSS 22, as shown in Appendix B (table B.1, page 91).

5.4.1 Illumination Observations at EMU Registrar Office

A digital lux- meter was used to get the required measurements, and initially the device was calibrated to ensure clear and accurate results. The table 5.14 next page represents those observations in 33 positions within the registrar office, and the measurement process was repeated at different times in each location due to varying lighting levels in that space.

Table 5.14: Illumination Measurements at EMU Registrar Office (lux)

Place	Right	Mid	Left	Place	Right	Mid	Left
1	582	532	570	18	827	864	858
2	560	882	862	19	863	916	812
3	878	906	880	20	818	835	631
4	968	872	903	21	786	732	850
5	1037	1020	1020	22	935	863	671
6	1026	941	958	23	938	904	858
7	826	804	846	24	800	782	633
8	808	900	735	25	882	618	846
9	901	936	966	26	870	874	680
10	911	771	739	27	834	920	952
11	762	800	550	28	336	321	340
12	606	745	689	29	412	365	316
13	930	851	974	30	553	626	442
14	697	840	875	31	684	913	907
15	631	585	460	32	578	545	490
16	512	588	590	33	222	218	225
17	773	786	661				

The illumination results show satisfactory level of light at the majority of places, but there were a very high ranges and difference between the observations, for example inside room the illumination level was only 221.7 lux although that the top ceiling was not high but the electricity light was not sufficient. In other places, specifically the left side of the entrance of the registration department, the lighting exceeded over 1000 lux. As a result of the place and the distribution of offices which provide natural light from the windows that spreads in the back walls, which is the real reason for the quality of light and clarity of vision levels.

The results of analyzing the observations were put in table 5.15 next page which shows a minimum value for right, middle and left positions by 222, 218 and 225 respectively, This implies that the illumination levels are under required level that is needed in the places. The illumination level at general offices should be 500 lux as it illustrated in table 3.2 page 20 in chapter 3.

Table 5.15: Illumination Measurements Results

		Right	middle	Left
	Valid	33	33	33
	Missing	0	0	0
Minimum		222	218	225
Maximum		1037	1020	1020

5.4.2 Optec Vision Test

The aim of the optec vision test is to identify who have problems and needs professional assistance. Good vision is a precious gift, which should be guarded, cherished, and nurtured throughout life. The test consists of two parts; the first is for far distances and the second is for near and direct distances such as reading and computer use.

5.4.2.1 Far Vision Test

Based on the questionnaire, which was distributed at the beginning of the study, some staff pointed to the lack of clarity of vision and lack of light and discomfort, the next step was taken to examine the eyes and consideration of all staff in the workplace, where all responded and the examinations were done by using a device (Optec Vision Tester) Which was provided through the Department of Industrial Engineering at EMU. Figure 5.3 and table 5.16 next page show the work and results obtained after statistical analysis. All individual results are shown in table B.1 in Appendix B in page 91).

Figure 5.3: Optec Vision Test at EMU Registrar Office

Table 5.16: Far Visual Acuity Test

	Acuity both eyes	Acuity right eye	Acuity left eye
N	19	19	19
Mean	7.95	6.26	6.05
Std. Deviation	3.659	3.984	3.535
Minimum	3	1	2
Maximum	14	14	13
Difficulty in Vision	7	11	10
Normal Vision	12	8	9
Proportion of Vision Issues %	37	58	53

The clarity or sharpness of vision is known visual acuity. By this definition there is 37% of employees haven't clarity of vision with both eyes. Also, the percent of the Acuity is 58% and 53% for right eye And left eye respectively. It means they can't see clearly for the far distance as the persons with normal vision.

The second part of the test was checking four measures; color, depth perception vertical phoria, and lateral phoria. The results were recorded next page in table 5.17, and other individual results was documented at the (Appendix B, table B.1, page 91). The term depth perception refers to our ability to determine distances between objects and see the world in three dimensions. Hyperphoria, or vertical phoria, is the tendency of one eye to deviate vertically. Lateral phoria is the loss of focusing ability. Color perception is the ability to focus on colors.

According to the above definitions there are negative results of depth perception and color perception. The was shown in table 5.17 below.

Table 5.17: Depth and Color Perception, Vertical and Lateral Phoria

	Depth perception	Color perception	Vertical phoria	Lateral phoria
N	19	19	19	19
Difficulty in Vision	9	4	2	2
Normal Vision	10	15	17	17
Proportion of Vision Issues %	47	21	11	11

To understand the nature of depth perception for far places as it is determined and controled by Optec vision tester, the experiment was to read 9 circles by both eyes which ring floats out. The difficulty to point out the floating ring increases in each of the nine steps in this series. On the other hand, the color perception test was containing six circles labeled by letters A, B to F, five of them have numbers but the last one was empty. There are a total of 8 numerals in the six circles, for normal color vision, circle F has no numerals in it, color deficient will read a 5. Color- normal subjects will answer the 8 numerals correctly and state there is nothing in circle F. 5 out of 8 numerals correct is mild color deficiency.

Another examination was done to check the vertical and lateral phoria. This test measures how the eyes work together in the vertical plane and the relative posture of the eyes in the lateral plane. In the vertical phoria test the red line passing through note number 4 is ideal orthophoric. Anywhere from 2.5 to 5.5 is the accepted norm. if the subject answers was between 1 to 4 that indicates left hyerphoria, 4 to 7 indicates right hyperphoria. The intersection of the right and left hyperphoria is the ideal level, it will be when the subject's answer is 4.

The lateral phoria shows the arrow above numbered notes, if the subject reads it 8 is ideal or orthophoric, pointing between 3.5 and 12.5 is the accepted norm. 1 to 8 indicates esophoria, 8 to 15 indicates exophoria. The following figure 5.4 shows the test of vertical and lateral phoria.

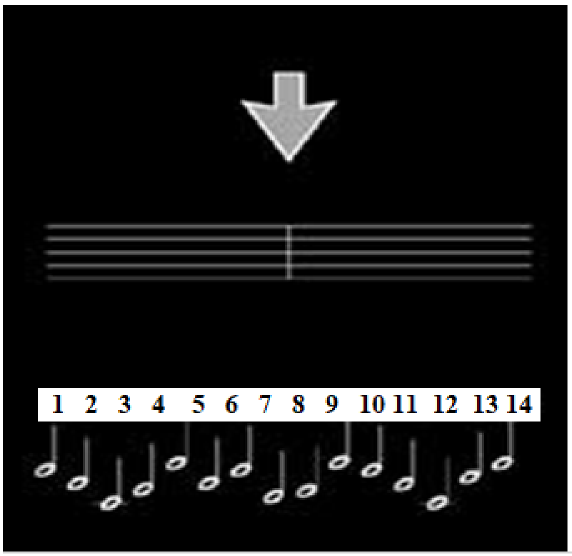


Figure 5.4: Lateral Phoria Test

5.4.2.2 Near Vision Test

The near vision test consists of four parts which are : acuity landolt rings (both eyes, right eye, and left eye), and lateral phoria. The acuity level extended to 14 targets to determine the broken ring correctly during the first three tests. If the subject experiences difficulty in seeing the targets, he/she cannot read more than target 7. Otherwise, reading after target 8 means that the acuity level will be more than 20/25. Table 5.14 shows the results that obtained from the employees in our experiment. The last test is lateral phoria as same as the far lateral test that explained before.

Table 5.18: Near Visual Acuity Test Results

Test	Near Acuity landlot rings(both eyes)	Acuity right eye	Acuity left eye	Lateral phoria
N	19	19	19	19
Difficulty in Vision	7	7	7	4
Normal Vision	12	12	12	15
Proportion of Vision Issues %	37	37	37	21

5.5 Sound Level and Noise Measurements

As it is shown in figure 5.5 below, the noise level was measured in the workplace at EMU registrar office on three different days and three times per day. 32 places are targeted which represent the whole space of the registration department. The sound level measurements in the 32 places are shown in figure 5.5 below.

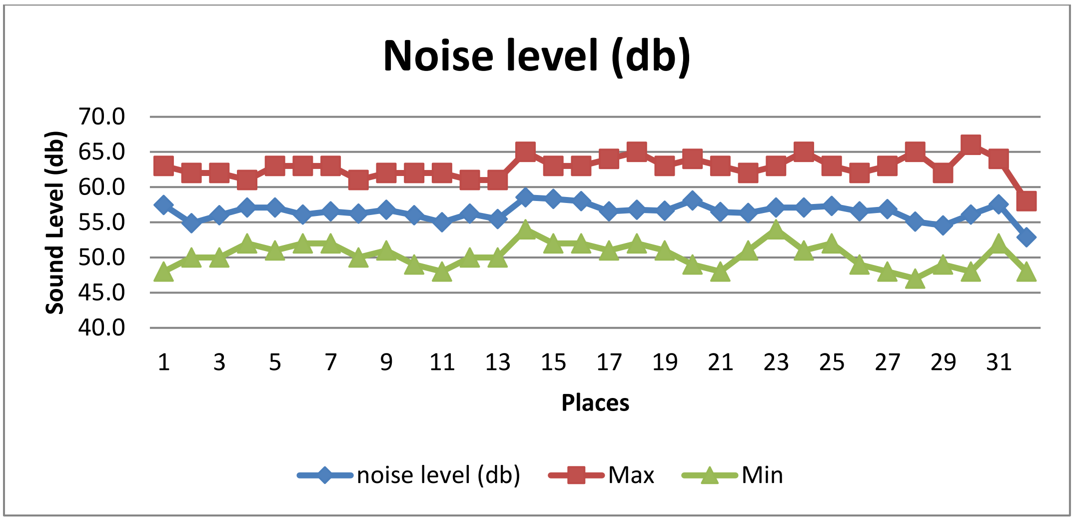


Figure 5.5: Sound Level Measurements at EMU Registrar Office

The maximum noise level was just over 65 dBA, and the minimum level was over 46 dBA. The range exceeded to 17 dBA during the different periods. The measurements of loudness not sufficient to decide if there is a high or no risk against the employee. It depends on the frequency of sound and the period of time that the noise extended.

Consequently, the average, maximum, minimum, and Std. deviation were calculated and put in table 5.19

Table 5.19: Noise Measurements

	N	Minimum dBA	Maximum dBA	Mean dBA	Std. Deviation
FRIDAY9	32	52.00	64.00	59.0938	3.63104
FRIDAY11	32	51.00	65.00	56.9063	3.60429
FRIDAY2	32	50.00	65.00	59.4375	3.60052
MONDAY9	32	47.00	61.00	52.6250	3.61672
MONDAY11	32	54.00	66.00	59.6875	3.11539
MONDAY2	32	48.00	63.00	55.9687	4.62451
TUESDAY9	32	51.00	63.00	55.9688	3.22775
TUESDAY11	32	50.00	63.00	55.0313	3.50561
TUESDAY2	32	47.00	59.00	53.7500	3.14181

During the work at EMU Reg. Office you cannot recognize and listen correctly from the first time. The closed place and small spaces between desks, also, free opened offices. The noise overlap and the focus becomes almost absent. So the problem is not necessarily directly on the ear or the ability to hear, but have an impact on the focus, response and speed of implementation.

5.5.1 Air Conduction Testing

Air conduction testing is used to measure the patient's hearing threshold levels. The test is usually started on the air with better hearing. That test was the second step of our research about hearing and noise effect on human safety of the employee. Industrial Engineering Department provided me by a Mico Audiometer to collect precise information of the employee hearing health and analyzing the collection data to decide if there is an effect of the work place on human health.

The audiometer helped us conduct the Air Conduction Test, and the results were transferred directly to a special model called Audiogram. The Audiogram consists of two main axes: the horizontal axis contains sound frequencies from 250 Hz to a maximum of 8000 Hz. The vertical axis contains a hearing level in decibels and starts from -10 to 110 dBA. (Table C.2 on page 100) in Appendix C contains the results of Audiometer test (Air Conduction Testing) below.

5.5.2 Audiogram Graphs

The objective of audiometric testing is to create an audiogram. The audiogram graphs hearing capacity, particularly, the softest sounds that can be heard in ears at different low-to-high frequencies. These sounds are called threshold. In fact, a man's listening ability threshold is characterized as "the softest sounds.

An audiogram is a graph, with frequency, from low to high, across the top or horizontal axis and intensity, from soft to loud, down the vertical axis. Audiogram draws the relation between loudness and frequency which is obtained from the audiometer. As we know the test inspects the right and left ear.

5.5.2.1 How to Read Audiogram

There are five levels distributed on the Audiogram in the form of rows, so that there is a specific range for each level, and each level of properties and controls are as follows

- Normal level: it's range of loudness is from 0 to 20 dBA. You can understand speech in a noisy environment and no amplification is needed.
- Mild hearing loss: the range of hearing loss extended between 20 and 40 dBA. Some difficulty hearing in noisy environments, also, subject needs a higher volume on TV or stereo and his/her family members often notice first.
- Moderate hearing loss: this level of hearing loss is between 40 and 70 dBA. You have difficulty understand speech in a noisy environment. Regularly, you ask people to repeat themselves. In general, you miss what people are saying and people say you talk too much.
- Severe hearing loss: from 70 to 90 dBA is the range of hearing loss and you have difficulty understand speech in most situations. You prefer avoiding noisy place.
- Profound level: it extends between 90 and 120 dBA and you experience major problems in all communication. This case requires visual assistance.

5.5.2.2 Types of Hearing loss

There are two types (shapes) of hearing loss depend on the degree and pattern of hearing loss across frequencies (tones): symmetrical and Asymmetrical. Symmetrical means the degree and configuration of hearing loss are the same in each ear.

Asymmetrical means the degree and configuration of hearing loss are different in each ear as shown in figures 5.9 and 5.10 next page.

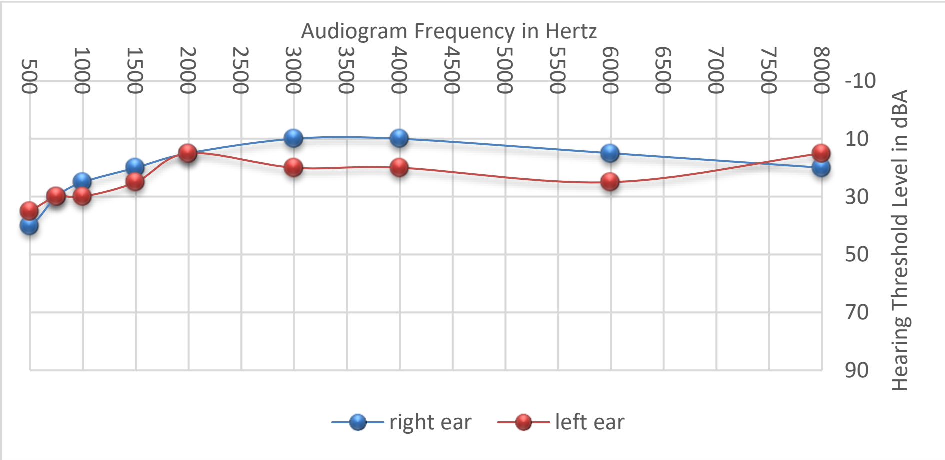


Figure 5.6: Audiogram (Normal level)

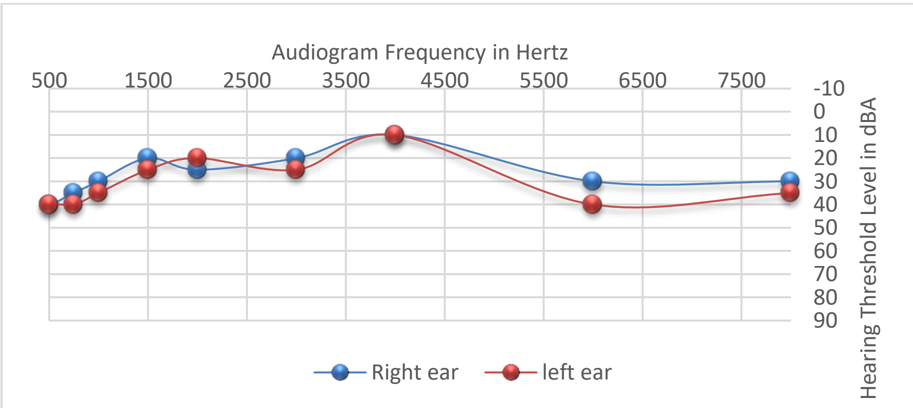


Figure 5.7: Audiogram (Symmetrical)

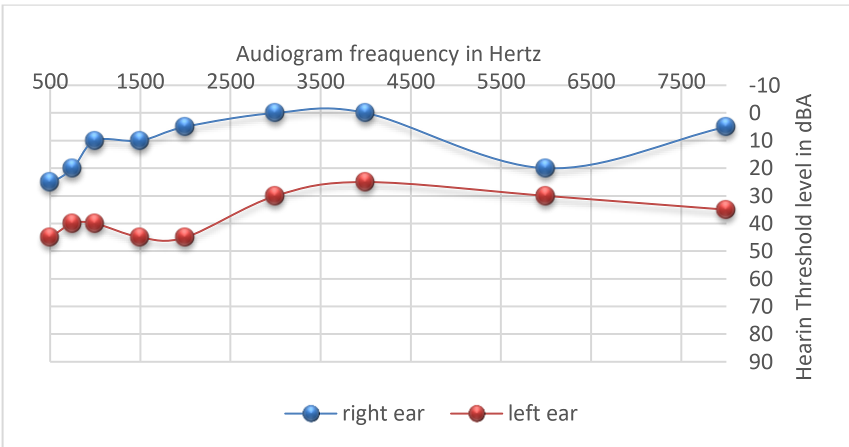


Figure 5.8: Audiogram (Asymmetrical)

According to the types and shapes of hearing loss the results of employees test showed about 21% of employee have hearing loss issues (moderate and severe level) and 5% have a high risk issues of hearing loss (severe level), the following result were cleared in table (5.16) below.

Table 5.20: Audiometer Test Results

Subject/Level	Normal	Mild	Moderate	Severe	Profound
Female	6	3	3	1	0
Male	5	1	0	0	0
Total	11	4	3	1	0
Percent %	58	21	16	5	0

All of results and types of audiogram are attached in appendix C from figure C.1 to figure C.18 in pages 101 to 107.

Chapter 6

CONCLUSION

Our Observations, in This Thesis Work and Recommendations Can be Summarized as Follow:

The workplace and space occupied by staff in the registration service are narrow and at close distances between staff and their offices, resulting in increased pressure of focus and impact on hearing and response capabilities. This requires a better solution in the geometric distribution of the place and the arrangement of furniture within the offices.

We realize that there are measurably difference between body measurements of female and male staff. This outlet helped us to indicate in the plan which standards of anthropometry parts ought to be utilized (e.g.. Outline for movable range, or plan for extraordinary or plan for normal). Along these lines, we could enhance the extent of coordinating technique and acquire the best coordinating rate for male and females employees.

There are different variations in the seats and the height of the tables and this causes muscle problems and pain in the shoulders and back affects the integrity of the spine and increases pressure on the joints.

There are a lot of seats damaged due to the length of the period of use and non-maintenance is a source of inconvenience and danger to the health and safety of staff, and must be replaced by convenience seats and comfortable.

The mismatch between anthropometric measurements and registrar office furniture were decreased or eliminated by the new proposed methods, for example the mismatch for seat height and popliteal height was decreased to 7% and 5% for female and male respectively.

The equipment design depends on the type of the part of furniture, sometimes the adjustable method more convenience than others to decrease the mismatch. On the hand, the extreme method of design very effective method to eliminate the mismatch. For example the seat width for male was 38.4 cm, this value is the maximum hip width and all male fit with this measurement.

The seat depth is 44 and it ought to be 39 cm as indicated by new anthropometric measurements. Also, the seat width and hip width mismatch: the current seat width is 45 and it ought to be changed to 38.4 and 52.8 cm for male and female respectively.

The results of the survey to measure the levels of lighting showed different variations between places, and in some places they were below the minimum level required. The workplace requires lighting of 500 lux to perform the work without any obstacle.

Natural luminescence, which is the source of excellent daylight, causes high levels of luminosity in some places with windows, but one flaw is the glare reflection on reflective surfaces.

The daylight is better than electric lighting, where not more than 218 lux in semi dark places that do not have sunlight, and the fact is high and need to be redistributed, especially in the winter and days when the light is dim and the sun disappears behind the clouds.

Since luminance is associated with vision, eye examinations have shown a decline in vision levels, depth of vision, and sometimes the disparity between the eyes and the same person.

The depth perception of vision values was about 75% for the employee and the minimum accepted level is 85%.

The maximum threshold of noise measurements was over 65 db, and the minimum rate was over 46 db. The range exceeded to 17 db during the different periods, this percent means there is no danger against the employees. Despite these results, the audiometer cleared a negative outputs as a shortage of hearing and moderate to several level of loss hearing.

The results of the tests showed that the majority of employees have problems, despite good lighting levels, and the expect reason is due to the frequent use of computer and mobile phone and conditions outside the work environment. I suggested the following solutions to reduce eye strain and decrease risk:

- Have your eyes examined annually by an eye doctor. If you wear glasses, consider a pair of glasses specifically designed for computer use. Also, consider glare coating on your lenses.
- Select a computer monitor with a larger and flat screen.

- To reduce glare, place your monitor perpendicular to a window, adjust or add window blinds, and reduce interior lighting to lower glare and reflections. Use a task light that shines only on your paper.
- Use an antiglare screen on your computer
- Take a vision break every 20 minutes or so and look, at an object 20 feet or more away to relax your eye muscles.

- Finally, noise tests also indicated that the level of sound in the building is normal but most of the staff suffer from hearing problems in at least one ear. This may be due to the use of mobile phones and intermittent noise, as well as noise from outside the working environment of cars and others.

Further Study that Can be Done:

A study of direct examination of muscle stress, specifically the areas of shoulders, arms, legs, and lower back, and its relation to anthropometric measurements and equipment design. It can be measured by Electromyogram (EMG).

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APPENDICES

Appendix A: Anthropometric Measurements of Eastern Mediterranean University Registrar Office Employees

Table A.1a: Anthropometric Measurements (Female, N= 14)

Subjects	Height	Shoulder Height	Shoulder Elbow Height	Buttock Popliteal Height	Popliteal Height	Knee Height	Forearm Hand length	Hip Width	Elbow Sitting Height	Sitting Height	Sitting Eye Height
1	169.00	56.60	40.60	48.60	45.50	47.30	36.70	52.80	22.00	87.40	74.40
2	168.20	55.90	40.00	38.00	54.00	54.40	44.20	35.00	25.70	78.30	70.70
3	156.00	56.10	31.50	41.80	53.00	50.70	38.70	29.80	17.70	69.20	57.10
4	160.20	55.30	38.00	49.60	53.80	52.30	33.20	37.90	20.00	63.70	52.90
5	162.00	58.00	40.30	50.30	54.20	50.40	43.80	35.00	20.00	65.70	53.70
6	166.00	54.00	32.50	42.50	50.20	51.00	43.00	38.50	21.70	79.50	67.00
7	167.00	53.00	30.00	43.20	49.00	50.50	45.00	29.70	19.70	79.00	66.00
8	168.00	54.20	30.30	47.60	43.60	42.80	41.80	43.70	22.00	80.00	69.80
9	171.00	48.50	30.00	43.50	51.00	50.50	41.30	26.80	16.70	82.00	72.00
10	154.00	49.00	26.70	35.80	50.50	39.70	30.60	33.50	20.20	78.00	68.00
11	170.00	57.50	30.20	47.30	48.60	53.80	40.00	42.00	20.40	84.00	76.00
12	160.00	47.30	29.30	38.20	56.00	49.00	36.20	36.80	20.30	78.00	71.00
13	158.00	63.20	32.00	42.30	54.40	50.50	39.90	35.60	18.80	70.10	59.20
14	165.00	54.00	39.20	40.20	55.20	52.80	44.40	36.00	22.20	73.30	61.70
Mean	163.886	56.286	33.614	43.493	51.357	49.693	39.914	36.650	20.529	76.300	65.679
Minimum	154.00	47.30	26.70	35.80	43.60	39.70	30.60	26.80	16.70	63.70	52.90
Maximum	171.00	82.00	40.60	50.30	56.00	54.40	45.00	52.80	25.70	87.40	76.00
Std. Deviation	5.491	8.4791	4.869	4.596	3.712	4.059	4.402	6.524	2.189	6.934	7.537
5th Percentile	154.83	42.3	25.58	35.91	45.24	42.99	32.65	25.89	16.92	64.86	53.24
95th Percentile	172.95	70.28	41.64	51.07	57.48	56.39	47.17	47.41	24.14	87.74	78.12

Table A.1b: Anthropometric Measurements (Male, N=6)

Subjects	Height	Shoulder Height	Shoulder Elbow Height	Buttock Popliteal Height	Popliteal Height	Knee Height	Forearm Hand length	Hip Width	Elbow Sitting Height	Sitting Height	Sitting Eye Height
1	184.00	60.30	42.50	50.70	55.50	53.90	46.70	38.10	25.50	86.00	75.00
2	177.70	61.00	39.00	49.40	54.50	50.30	44.20	38.40	23.80	84.20	76.90
3	172.00	56.00	33.30	44.00	46.60	51.20	45.50	32.50	19.50	81.00	67.50
4	170.00	54.00	30.90	42.00	45.20	49.80	44.40	35.20	18.70	79.40	65.00
5	172.00	59.30	32.60	50.20	52.50	55.40	44.80	38.30	20.20	86.10	77.90
6	170.00	58.00	41.20	41.30	54.40	54.60	42.20	38.40	20.30	80.20	71.40
Mean	174.283	58.100	36.583	46.267	51.450	52.533	44.633	36.817	21.333	82.817	72.283
Minimum	170.00	54.00	30.90	41.30	45.20	49.80	42.20	32.50	18.70	79.40	65.00
Maximum	184.00	61.00	42.50	50.70	55.50	55.40	46.70	38.40	25.50	86.10	77.90
Std. Deviation	5.536	2.680	4.922	4.312	4.430	2.391	1.498	2.454	2.687	2.989	5.234
5^{th} Percentile	165.15	53.68	28.46	39.16	44.14	48.58	42.16	32.77	16.9	77.89	63.64
95^{th} percentile	183.41	62.52	44.7	53.83	58.76	56.48	47.10	40.87	25.76	87.75	80.92

Table A.1c: Overall Anthropometric Measurements (Female & Male, N=20)

Subjects	Height	Shoulder Height	Shoulder Elbow Height	Buttock Popliteal Height	Popliteal Height	Knee Height	Forearm Hand length	Hip Width	Elbow Sitting Height	Sitting Height	Sitting Eye Height
Mean	167.0050	56.8300	34.5050	44.3250	51.3850	50.5450	41.3300	36.7000	20.7700	78.2550	67.6600
Minimum	154.00	47.30	26.70	35.80	43.60	39.70	30.60	26.80	16.70	63.70	52.90
Maximum	184.00	63.20	42.50	50.70	56.00	55.40	46.70	52.80	25.70	87.40	77.90
Std. Deviation	7.25175	7.19789	4.95426	4.58784	3.82021	3.81624	4.33251	5.54180	2.30699	6.68057	7.46447

Table A.2: Proportion of Employees Match at Different Seat Height(Female)

SH	SH/COS(5)	SH/COS(30)	Z1	Z2	P1	P2	P2-P1
38	38.15	43.88	-3.56	-2.02	0.00	0.02	0.02
39	39.16	45.03	-3.29	-1.70	0.00	0.04	0.04
40	40.16	46.19	-3.02	-1.39	0.00	0.08	0.08
41	41.16	47.34	-2.75	-1.08	0.00	0.14	0.14
42	42.17	48.50	-2.48	-0.77	0.01	0.22	0.21
43	43.17	49.65	-2.21	-0.46	0.01	0.32	0.309
44	44.18	50.81	-1.94	-0.15	0.03	0.44	0.414
45	45.18	51.96	-1.67	0.16	0.05	0.56	0.517
46	46.18	53.12	-1.39	0.47	0.08	0.68	0.60
47	47.19	54.27	-1.12	0.79	0.13	0.78	0.65
48	48.19	55.43	-0.85	1.10	0.20	0.86	0.67
49	49.20	56.58	-0.58	1.41	0.28	0.92	0.64
50	50.20	57.74	-0.31	1.72	0.38	0.96	0.58
51	51.20	58.89	-0.04	2.03	0.48	0.98	0.50
52	52.21	60.05	0.23	2.34	0.59	0.99	0.40

Table A.3: Proportion of Employees Match at Different Seat Height (Male)

SH	SH/COS(5)	SH/COS(30)	Z1	Z2	P1	P2	P2-P1
38	38.15	43.88	-3.00	-1.71	0.00	0.04	0.04
39	39.16	45.03	-2.78	-1.45	0.00	0.07	0.07
40	40.16	46.19	-2.55	-1.19	0.01	0.12	0.11
41	41.16	47.34	-2.32	-0.93	0.01	0.18	0.17
42	42.17	48.50	-2.10	-0.67	0.02	0.25	0.23
43	43.17	49.65	-1.87	-0.41	0.03	0.34	0.312
44	44.18	50.81	-1.64	-0.14	0.05	0.44	0.392
45	45.18	51.96	-1.42	0.12	0.08	0.55	0.468
46	46.18	53.12	-1.19	0.38	0.12	0.65	0.53
47	47.19	54.27	-0.96	0.64	0.17	0.74	0.57
48	48.19	55.43	-0.74	0.90	0.23	0.82	0.58
49	49.20	56.58	-0.51	1.16	0.31	0.88	0.57
50	50.20	57.74	-0.28	1.42	0.39	0.92	0.53
51	51.20	58.89	-0.06	1.68	0.48	0.95	0.48
52	52.21	60.05	0.17	1.94	0.57	0.97	0.41

Table A.4: Proportion of Employees Match at Different Seat Depth

SD	SD/0.95	SD/0.8	Z1	Z2	L	U	Proportion of Match (%)
28	29.47	35	-3.23	-2.03	0.00	0.02	0.02
29	30.53	36.25	-3.01	-1.76	0.00	0.04	0.04
30	31.58	37.5	-2.78	-1.49	0.00	0.07	0.07
31	32.63	38.75	-2.55	-1.21	0.01	0.11	0.11
32	33.68	40	-2.32	-0.94	0.01	0.17	0.16
33	34.74	41.25	-2.09	-0.67	0.02	0.25	0.23
34	35.79	42.5	-1.86	-0.40	0.03	0.35	0.31
35	36.84	43.75	-1.63	-0.12	0.05	0.45	0.40
36	37.89	45	-1.40	0.15	0.08	0.56	0.48
37	38.95	46.25	-1.17	0.42	0.12	0.66	0.54
38	40.00	47.5	-0.94	0.69	0.17	0.76	0.58
39	41.05	48.75	-0.71	0.97	0.24	0.83	0.59
40	42.11	50	-0.48	1.24	0.31	0.89	0.58
41	43.16	51.25	-0.25	1.51	0.40	0.93	0.53
42	44.21	52.5	-0.02	1.78	0.49	0.96	0.47
43	45.26	53.75	0.21	2.05	0.58	0.98	0.40
44	46.32	55	0.43	2.33	0.67	0.99	0.32
45	47.37	56.25	0.66	2.60	0.75	1.00	0.25
46	48.42	57.5	0.89	2.87	0.81	1.00	0.18
47	49.47	58.75	1.12	3.14	0.87	1.00	0.13
48	50.53	60	1.35	3.42	0.91	1.00	0.09
49	51.58	61.25	1.58	3.69	0.94	1.00	0.06
50	52.63	62.5	1.81	3.96	0.96	1.00	0.04
51	53.68	63.75	2.04	4.23	0.98	1.00	0.02

Table A.5a: Proportion of Employees Match at Different Seat Width (Female)

Seat width	SW/1.3	SW/1.1	Z1	Z2	P1	P2	Proportion of Match (%)
28	21.54	25.45	-2.73	-2.02	0.00	0.02	0.02
29	22.31	26.36	-2.59	-1.86	0.00	0.03	0.03
30	23.08	27.27	-2.45	-1.69	0.01	0.05	0.04
31	23.85	28.18	-2.31	-1.53	0.01	0.06	0.05
32	24.62	29.09	-2.18	-1.36	0.01	0.09	0.07
33	25.38	30.00	-2.04	-1.20	0.02	0.11	0.09
34	26.15	30.91	-1.90	-1.04	0.03	0.15	0.12
35	26.92	31.82	-1.76	-0.87	0.04	0.19	0.15
36	27.69	32.73	-1.63	-0.71	0.05	0.24	0.19
37	28.46	33.64	-1.49	-0.54	0.07	0.29	0.22
38	29.23	34.55	-1.35	-0.38	0.09	0.35	0.26
39	30.00	35.45	-1.21	-0.22	0.11	0.41	0.30
40	30.77	36.36	-1.07	-0.05	0.14	0.48	0.34
41	31.54	37.27	-0.93	0.11	0.18	0.54	0.37
42	32.31	38.18	-0.79	0.28	0.21	0.61	0.39
43	33.08	39.09	-0.65	0.44	0.26	0.67	0.41
44	33.85	40.00	-0.52	0.60	0.30	0.73	0.42
45	34.62	40.91	-0.38	0.77	0.35	0.78	0.43
46	35.38	41.82	-0.24	0.93	0.41	0.82	0.42
47	36.15	42.73	-0.10	1.10	0.46	0.86	0.40
48	36.92	43.64	0.04	1.26	0.52	0.90	0.38
49	37.69	44.55	0.18	1.43	0.57	0.92	0.35
50	38.46	45.45	0.32	1.59	0.62	0.94	0.32
51	39.23	46.36	0.46	1.75	0.68	0.96	0.28
52	40	47.27	0.60	1.92	0.72	0.97	0.25
53	40.77	48.18	0.73	2.08	0.77	0.98	0.21
54	41.54	49.09	0.87	2.25	0.81	0.99	0.18
55	42.31	50.00	1.01	2.41	0.84	0.99	0.15
56	43.08	50.91	1.15	2.57	0.88	0.99	0.12
57	43.85	51.82	1.29	2.74	0.90	1.00	0.10
58	44.62	52.73	1.43	2.90	0.92	1.00	0.07
59	45.38	53.64	1.57	3.07	0.94	1.00	0.06
60	46.15	54.55	1.71	3.23	0.96	1.00	0.04
61	46.92	55.45	1.85	3.39	0.97	1.00	0.03
62	47.69	56.36	1.98	3.56	0.98	1.00	0.02

Table A.5b: Proportion of Employees Match at Different Seat Width (Male)

Seat width	SW/1.3	SW/1.1	Z1	Z2	P1	P2	Proportion of Match (%)
28	21.54	25.45	-2.76	-2.05	0.00	0.02	0.02
29	22.31	26.36	-2.62	-1.89	0.00	0.03	0.03
30	23.08	27.27	-2.48	-1.72	0.01	0.04	0.04
31	23.85	28.18	-2.34	-1.56	0.01	0.06	0.05
32	24.62	29.09	-2.20	-1.40	0.01	0.08	0.07
33	25.38	30.00	-2.06	-1.23	0.02	0.11	0.09
34	26.15	30.91	-1.93	-1.07	0.03	0.14	0.12
35	26.92	31.82	-1.79	-0.90	0.04	0.18	0.15
36	27.69	32.73	-1.65	-0.74	0.05	0.23	0.18
37	28.46	33.64	-1.51	-0.57	0.07	0.28	0.22
38	29.23	34.55	-1.37	-0.41	0.09	0.34	0.26
39	30.00	35.45	-1.23	-0.25	0.11	0.40	0.29
40	30.77	36.36	-1.09	-0.08	0.14	0.47	0.33
41	31.54	37.27	-0.95	0.08	0.17	0.53	0.36
42	32.31	38.18	-0.81	0.25	0.21	0.60	0.39
43	33.08	39.09	-0.68	0.41	0.25	0.66	0.41
44	33.85	40.00	-0.54	0.57	0.30	0.72	0.42
45	34.62	40.91	-0.40	0.74	0.35	0.77	0.42
46	35.38	41.82	-0.26	0.90	0.40	0.82	0.42
47	36.15	42.73	-0.12	1.07	0.45	0.86	0.40
48	36.92	43.64	0.02	1.23	0.51	0.89	0.38
49	37.69	44.55	0.16	1.39	0.56	0.92	0.36
50	38.46	45.45	0.30	1.56	0.62	0.94	0.32
51	39.23	46.36	0.44	1.72	0.67	0.96	0.29
52	40	47.27	0.57	1.89	0.72	0.97	0.25
53	40.77	48.18	0.71	2.05	0.76	0.98	0.22
54	41.54	49.09	0.85	2.21	0.80	0.99	0.18
55	42.31	50.00	0.99	2.38	0.84	0.99	0.15
56	43.08	50.91	1.13	2.54	0.87	0.99	0.12
57	43.85	51.82	1.27	2.71	0.90	1.00	0.10
58	44.62	52.73	1.41	2.87	0.92	1.00	0.08
59	45.38	53.64	1.55	3.04	0.94	1.00	0.06
60	46.15	54.55	1.68	3.20	0.95	1.00	0.05
61	46.92	55.45	1.82	3.36	0.97	1.00	0.03
62	47.69	56.36	1.96	3.53	0.98	1.00	0.02

Table A.6a: Proportion of Employees Match at Different Backrest Height (F&M)

Backrest Height	BH/0.8	BH/.6	Z1	Z2	L	U	Proportion of Match
25	31.25	41.67	-3.55	-2.11	0.00	0.02	0.02
26	32.5	43.33	-3.38	-1.87	0.00	0.03	0.03
27	33.75	45.00	-3.21	-1.64	0.00	0.05	0.05
28	35	46.67	-3.03	-1.41	0.00	0.08	0.08
29	36.25	48.33	-2.86	-1.18	0.00	0.12	0.12
30	37.5	50.00	-2.68	-0.95	0.00	0.17	0.17
31	38.75	51.67	-2.51	-0.72	0.01	0.24	0.23
32	40	53.33	-2.34	-0.49	0.01	0.31	0.30
33	41.25	55.00	-2.16	-0.25	0.02	0.40	0.38
34	42.5	56.67	-1.99	-0.02	0.02	0.49	0.47
35	43.75	58.33	-1.82	0.21	0.03	0.58	0.55
36	45	60.00	-1.64	0.44	0.05	0.67	0.62
37	46.25	61.67	-1.47	0.67	0.07	0.75	0.68
38	47.5	63.33	-1.30	0.90	0.10	0.82	0.72
39	48.75	65.00	-1.12	1.13	0.13	0.87	0.741
40	50	66.67	-0.95	1.37	0.17	0.91	0.743
41	51.25	68.33	-0.78	1.60	0.22	0.94	0.73
42	52.5	70.00	-0.60	1.83	0.27	0.97	0.69
43	53.75	71.67	-0.43	2.06	0.33	0.98	0.65
44	55	73.33	-0.25	2.29	0.40	0.99	0.59
45	56.25	75.00	-0.08	2.52	0.47	0.99	0.53
46	57.5	76.67	0.09	2.76	0.54	1.00	0.46
47	58.75	78.33	0.27	2.99	0.61	1.00	0.39
48	60	80.00	0.44	3.22	0.67	1.00	0.33
49	61.25	81.67	0.61	3.45	0.73	1.00	0.27
50	62.5	83.33	0.79	3.68	0.78	1.00	0.22
51	63.75	85.00	0.96	3.91	0.83	1.00	0.17
52	65	86.67	1.13	4.14	0.87	1.00	0.13
53	66.25	88.33	1.31	4.38	0.90	1.00	0.10
54	67.5	90.00	1.48	4.61	0.93	1.00	0.07
55	68.75	91.67	1.66	4.84	0.95	1.00	0.05

Table A.6b: Proportion of Employees Match at Different Backrest Height (Female)

Backrest Height	BH/0.8	BH/.6	Z1	Z2	P1	P2	Proportion of Match (%)
25	31.25	41.67	-3.02	-1.79	0.00	0.04	0.04
26	32.5	43.33	-2.87	-1.59	0.00	0.06	0.05
27	33.75	45.00	-2.72	-1.40	0.00	0.08	0.08
28	35	46.67	-2.57	-1.20	0.01	0.12	0.11
29	36.25	48.33	-2.43	-1.00	0.01	0.16	0.15
30	37.5	50.00	-2.28	-0.81	0.01	0.21	0.20

31	38.75	51.67	-2.13	-0.61	0.02	0.27	0.25
32	40	53.33	-1.98	-0.41	0.02	0.34	0.32
33	41.25	55.00	-1.84	-0.22	0.03	0.41	0.38
34	42.5	56.67	-1.69	-0.02	0.05	0.49	0.45
35	43.75	58.33	-1.54	0.18	0.06	0.57	0.51
36	45	60.00	-1.40	0.37	0.08	0.65	0.56
37	46.25	61.67	-1.25	0.57	0.11	0.72	0.61
38	47.5	63.33	-1.10	0.77	0.14	0.78	0.64
39	48.75	65.00	-0.95	0.96	0.17	0.83	0.66
40	50	66.67	-0.81	1.16	0.21	0.88	0.67
41	51.25	68.33	-0.66	1.36	0.26	0.91	0.66
42	52.5	70.00	-0.51	1.55	0.30	0.94	0.63
43	53.75	71.67	-0.36	1.75	0.36	0.96	0.60
44	55	73.33	-0.22	1.95	0.41	0.97	0.56
45	56.25	75.00	-0.07	2.14	0.47	0.98	0.51
46	57.5	76.67	0.08	2.34	0.53	0.99	0.46
47	58.75	78.33	0.23	2.54	0.59	0.99	0.40
48	60	80.00	0.37	2.73	0.65	1.00	0.35
49	61.25	81.67	0.52	2.93	0.70	1.00	0.30
50	62.5	83.33	0.67	3.13	0.75	1.00	0.25
51	63.75	85.00	0.82	3.32	0.79	1.00	0.21
52	65	86.67	0.96	3.52	0.83	1.00	0.17
53	66.25	88.33	1.11	3.72	0.87	1.00	0.13
54	67.5	90.00	1.26	3.91	0.90	1.00	0.10
55	68.75	91.67	1.41	4.11	0.92	1.00	0.08

Table A.6c: Proportion of Employees Match at Different Backrest Height (Male)

Backrest Height	BH/0.8	BH/.6	Z1	Z2	P1	P2	Proportion of Match (%)
25	31.25	41.67	-9.54	-5.66	0.00	0.00	0.00
26	32.5	43.33	-9.08	-5.04	0.00	0.00	0.00
27	33.75	45.00	-8.61	-4.41	0.00	0.00	0.00
28	35	46.67	-8.15	-3.79	0.00	0.00	0.00
29	36.25	48.33	-7.68	-3.17	0.00	0.00	0.00
30	37.5	50.00	-7.21	-2.55	0.00	0.01	0.01
31	38.75	51.67	-6.75	-1.93	0.00	0.03	0.03
32	40	53.33	-6.28	-1.30	0.00	0.10	0.10
33	41.25	55.00	-5.81	-0.68	0.00	0.25	0.25
34	42.5	56.67	-5.35	-0.06	0.00	0.48	0.48
35	43.75	58.33	-4.88	0.56	0.00	0.71	0.71
36	45	60.00	-4.41	1.18	0.00	0.88	0.88
37	46.25	61.67	-3.95	1.80	0.00	0.96	0.96
38	47.5	63.33	-3.48	2.43	0.00	0.99	0.99
39	48.75	65.00	-3.01	3.05	0.00	1.00	1.00
40	50	66.67	-2.55	3.67	0.01	1.00	0.99
41	51.25	68.33	-2.08	4.29	0.02	1.00	0.98
42	52.5	70.00	-1.62	4.91	0.05	1.00	0.95
43	53.75	71.67	-1.15	5.54	0.13	1.00	0.87
44	55	73.33	-0.68	6.16	0.25	1.00	0.75
45	56.25	75.00	-0.22	6.78	0.41	1.00	0.59
46	57.5	76.67	0.25	7.40	0.60	1.00	0.40
47	58.75	78.33	0.72	8.02	0.76	1.00	0.24
48	60	80.00	1.18	8.65	0.88	1.00	0.12
49	61.25	81.67	1.65	9.27	0.95	1.00	0.05
50	62.5	83.33	2.12	9.89	0.98	1.00	0.02
51	63.75	85.00	2.58	10.51	1.00	1.00	0.00
52	65	86.67	3.05	11.13	1.00	1.00	0.00
53	66.25	88.33	3.51	11.75	1.00	1.00	0.00
54	67.5	90.00	3.98	12.38	1.00	1.00	0.00
55	68.75	91.67	4.45	13.00	1.00	1.00	0.00

Table A.7a: Proportion of Employees Match at Different Desk Height (Female)

Table Height	EH	ES	Z1	Z2	Lower Bound	Upper Bound	Proportion of Match (%)
78.5	36.932	30.69	7.38	4.53	1.00	1.00	0.00
78	36.432	30.19	7.15	4.30	1.00	1.00	0.00
77.5	35.932	29.69	6.93	4.08	1.00	1.00	0.00
77	35.432	29.19	6.70	3.85	1.00	1.00	0.00
76.5	34.932	28.69	6.47	3.62	1.00	1.00	0.00
76	34.432	28.19	6.24	3.39	1.00	1.00	0.00
75.5	33.932	27.69	6.01	3.16	1.00	1.00	0.00
75	33.432	27.19	5.78	2.93	1.00	1.00	0.00
74.5	32.932	26.69	5.56	2.71	1.00	1.00	0.00
74	32.432	26.19	5.33	2.48	1.00	0.99	0.01
73.5	31.932	25.69	5.10	2.25	1.00	0.99	0.01
73	31.432	25.19	4.87	2.02	1.00	0.98	0.02
72.5	30.932	24.69	4.64	1.79	1.00	0.96	0.04
72	30.432	24.19	4.41	1.56	1.00	0.94	0.06
71.5	29.932	23.69	4.19	1.33	1.00	0.91	0.09
71	29.432	23.19	3.96	1.11	1.00	0.87	0.13
70.5	28.932	22.69	3.73	0.88	1.00	0.81	0.19
70	28.432	22.19	3.50	0.65	1.00	0.74	0.26
69.5	27.932	21.69	3.27	0.42	1.00	0.66	0.34
69	27.432	21.19	3.04	0.19	1.00	0.58	0.42
68.5	26.932	20.69	2.81	-0.04	1.00	0.49	0.51
68	26.432	20.19	2.59	-0.26	1.00	0.40	0.60
67.5	25.932	19.69	2.36	-0.49	0.99	0.31	0.69
67	25.432	19.19	2.13	-0.72	0.98	0.24	0.76
66.5	24.932	18.69	1.90	-0.95	0.97	0.17	0.83
66	24.432	18.19	1.67	-1.18	0.95	0.12	0.88
65.5	23.932	17.69	1.44	-1.41	0.93	0.08	0.92
65	23.432	17.19	1.22	-1.63	0.89	0.05	0.95
64.5	22.932	16.69	0.99	-1.86	0.84	0.03	0.97
64	22.432	16.19	0.76	-2.09	0.78	0.02	0.98
63.5	21.932	15.69	0.53	-2.32	0.70	0.01	0.99
63	21.432	15.19	0.30	-2.55	0.62	0.01	0.99
62.5	20.932	14.69	0.07	-2.78	0.53	0.00	1.00
62	20.432	14.19	-0.15	-3.01	0.44	0.00	1.00
61.5	19.932	13.69	-0.38	-3.23	0.35	0.00	1.00
61	19.432	13.19	-0.61	-3.46	0.27	0.00	1.00
60.5	18.932	12.69	-0.84	-3.69	0.20	0.00	1.00
60	18.432	12.19	-1.07	-3.92	0.14	0.00	1.00
59.5	17.932	11.69	-1.30	-4.15	0.10	0.00	1.00
59	17.432	11.19	-1.52	-4.38	0.06	0.00	1.00
58.5	16.932	10.69	-1.75	-4.60	0.04	0.00	1.00
58	16.432	10.19	-1.98	-4.83	0.02	0.00	1.00
57.5	15.932	9.69	-2.21	-5.06	0.01	0.00	1.00
57	15.432	9.19	-2.44	-5.29	0.01	0.00	1.00

Table A.7b: Proportion of Employees Match at Different Desk Height (Male)

Table Height	EH	ES	Z1	Z2	Lower Bound	Upper Bound	Proportion of Match (%)
78.5	36.932	30.69	6.01	3.69	1.00	1.00	0.00
78	36.432	30.19	5.82	3.50	1.00	1.00	0.00
77.5	35.932	29.69	5.64	3.32	1.00	1.00	0.00
77	35.432	29.19	5.45	3.13	1.00	1.00	0.00
76.5	34.932	28.69	5.26	2.94	1.00	1.00	0.00
76	34.432	28.19	5.08	2.76	1.00	1.00	0.00
75.5	33.932	27.69	4.89	2.57	1.00	0.99	0.01
75	33.432	27.19	4.71	2.39	1.00	0.99	0.01
74.5	32.932	26.69	4.52	2.20	1.00	0.99	0.01
74	32.432	26.19	4.34	2.02	1.00	0.98	0.02
73.5	31.932	25.69	4.15	1.83	1.00	0.97	0.03
73	31.432	25.19	3.96	1.64	1.00	0.95	0.05
72.5	30.932	24.69	3.78	1.46	1.00	0.93	0.07
72	30.432	24.19	3.59	1.27	1.00	0.90	0.10
71.5	29.932	23.69	3.41	1.09	1.00	0.86	0.14
71	29.432	23.19	3.22	0.90	1.00	0.82	0.18
70.5	28.932	22.69	3.03	0.71	1.00	0.76	0.24
70	28.432	22.19	2.85	0.53	1.00	0.70	0.30
69.5	27.932	21.69	2.66	0.34	1.00	0.63	0.37
69	27.432	21.19	2.48	0.16	0.99	0.56	0.44
68.5	26.932	20.69	2.29	-0.03	0.99	0.49	0.51
68	26.432	20.19	2.10	-0.21	0.98	0.41	0.59
67.5	25.932	19.69	1.92	-0.40	0.97	0.34	0.66
67	25.432	19.19	1.73	-0.59	0.96	0.28	0.72
66.5	24.932	18.69	1.55	-0.77	0.94	0.22	0.78
66	24.432	18.19	1.36	-0.96	0.91	0.17	0.83
65.5	23.932	17.69	1.18	-1.14	0.88	0.13	0.87
65	23.432	17.19	0.99	-1.33	0.84	0.09	0.91
64.5	22.932	16.69	0.80	-1.52	0.79	0.06	0.94
64	22.432	16.19	0.62	-1.70	0.73	0.04	0.96
63.5	21.932	15.69	0.43	-1.89	0.67	0.03	0.97
63	21.432	15.19	0.25	-2.07	0.60	0.02	0.98
62.5	20.932	14.69	0.06	-2.26	0.52	0.01	0.99
62	20.432	14.19	-0.13	-2.45	0.45	0.01	0.99
61.5	19.932	13.69	-0.31	-2.63	0.38	0.00	1.00
61	19.432	13.19	-0.50	-2.82	0.31	0.00	1.00
60.5	18.932	12.69	-0.68	-3.00	0.25	0.00	1.00
60	18.432	12.19	-0.87	-3.19	0.19	0.00	1.00
59.5	17.932	11.69	-1.06	-3.37	0.15	0.00	1.00
59	17.432	11.19	-1.24	-3.56	0.11	0.00	1.00
58.5	16.932	10.69	-1.43	-3.75	0.08	0.00	1.00
58	16.432	10.19	-1.61	-3.93	0.05	0.00	1.00
57.5	15.932	9.69	-1.80	-4.12	0.04	0.00	1.00
57	15.432	9.19	-1.98	-4.30	0.02	0.00	1.00

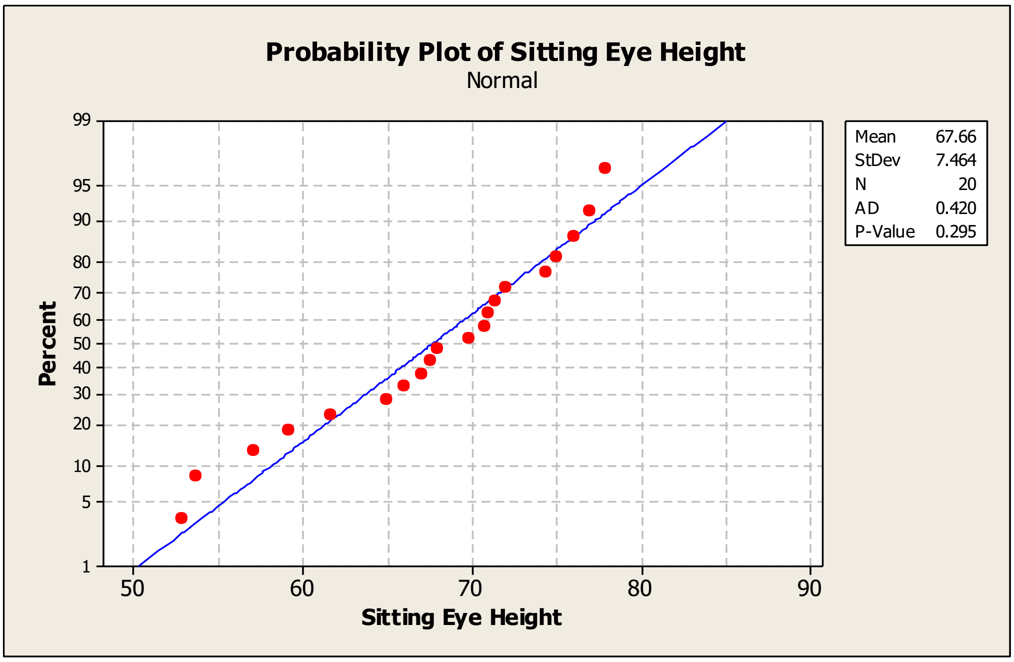

Figure A.1: Normality of Sitting Eye height

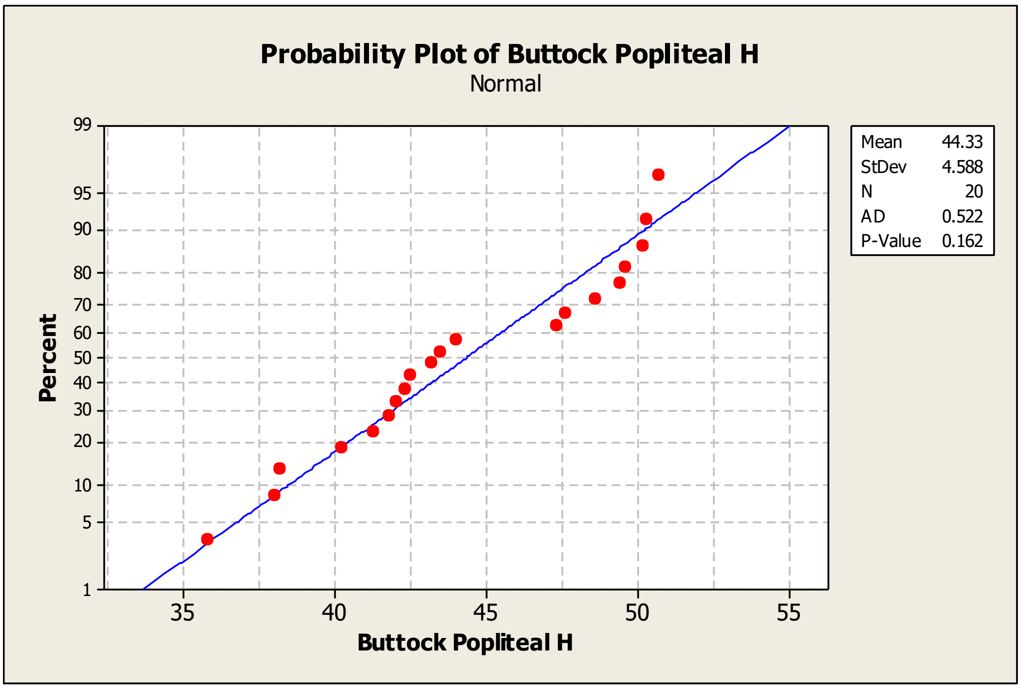

Figure A.2: Normality of Buttock Popliteal Height

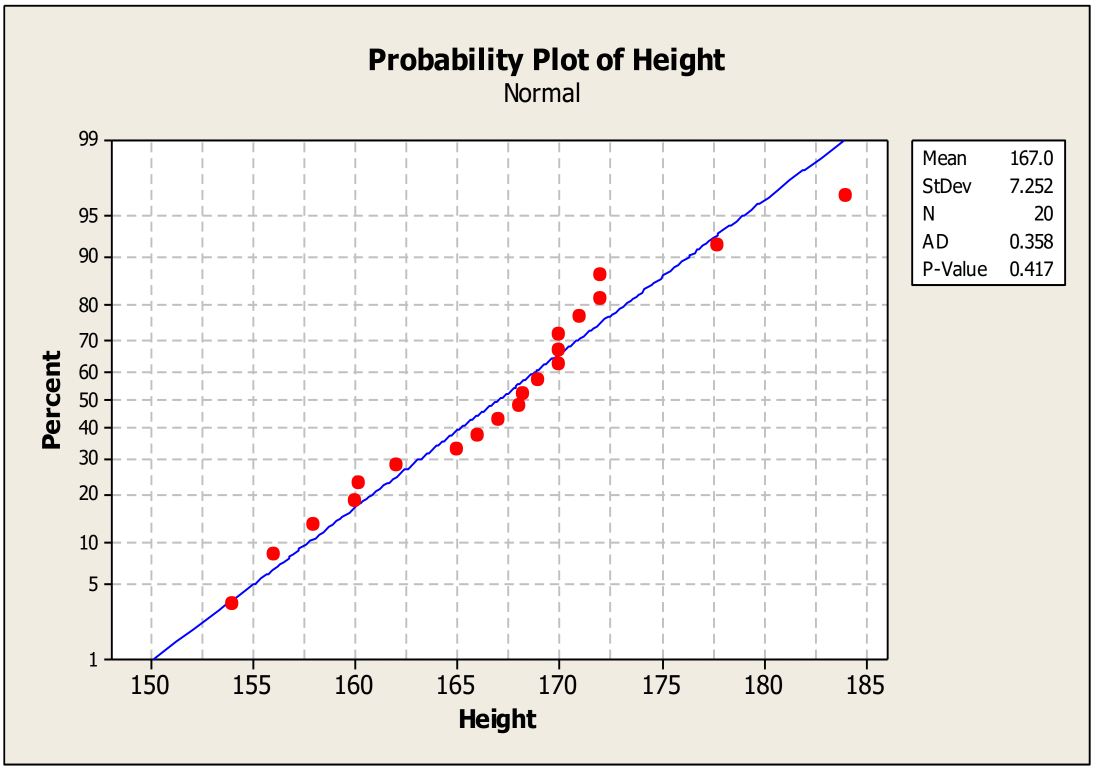

Figure A.3: Normality of Height Measurement

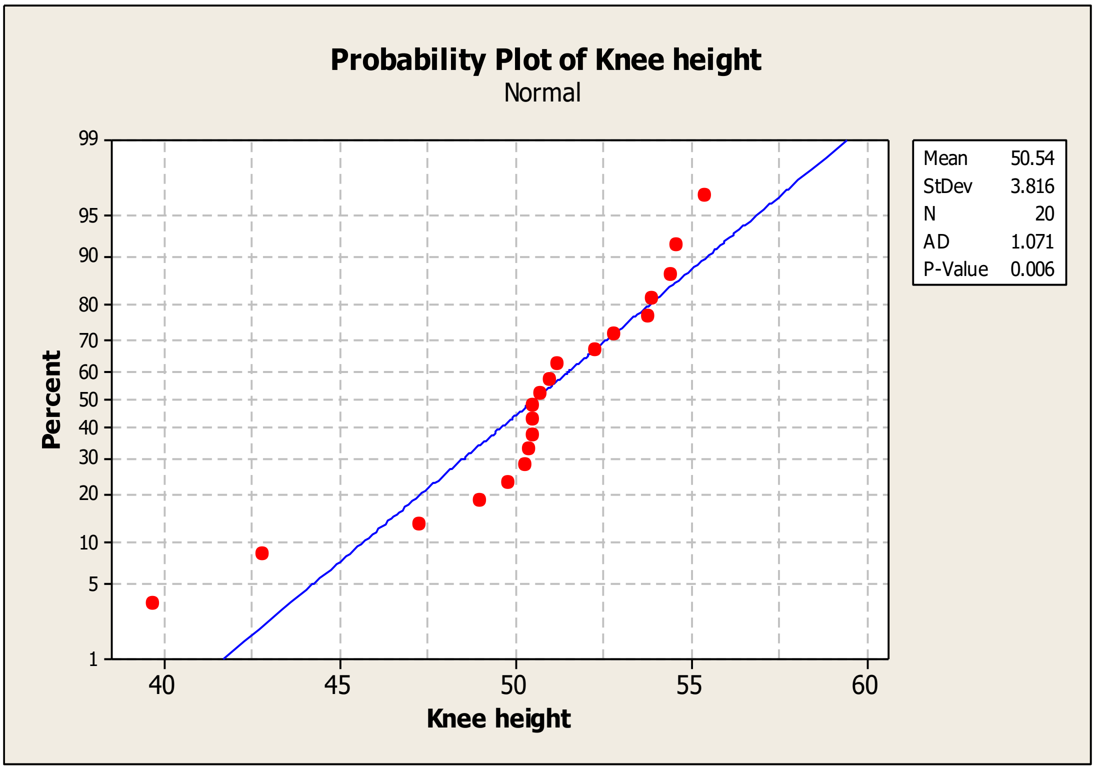

Figure A.4: Normality of Knee Height Measurement

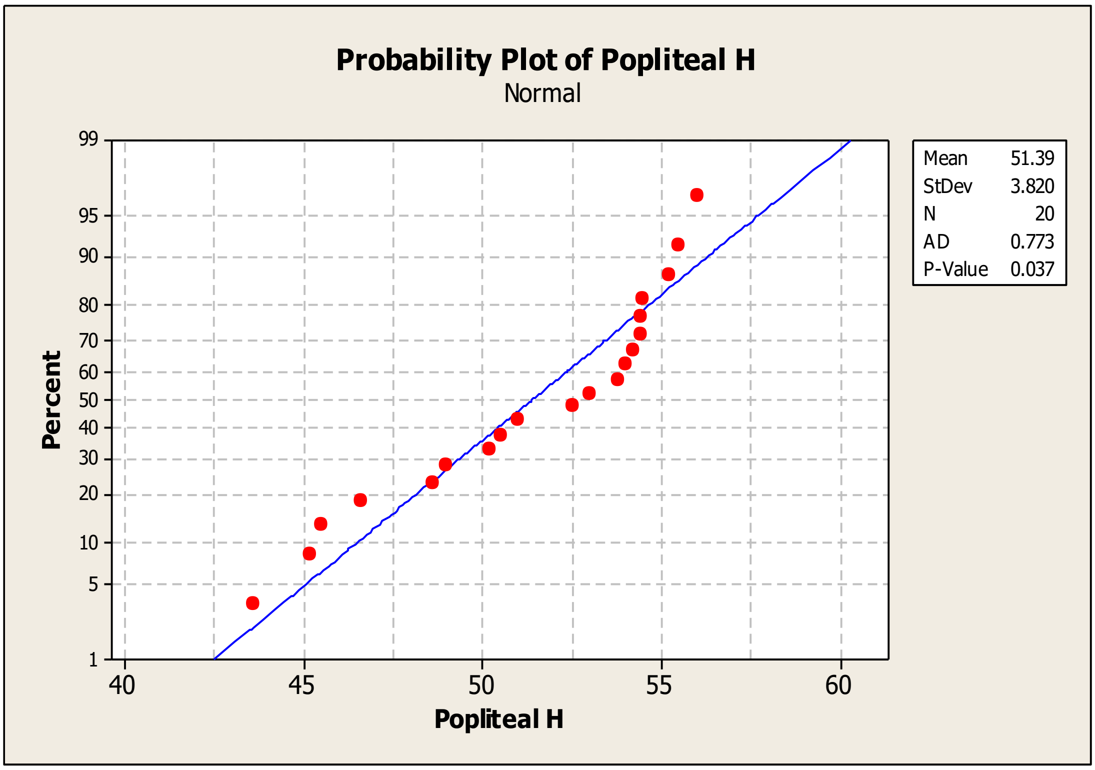

Figure A.5: Normality of Popliteal Height Measurement

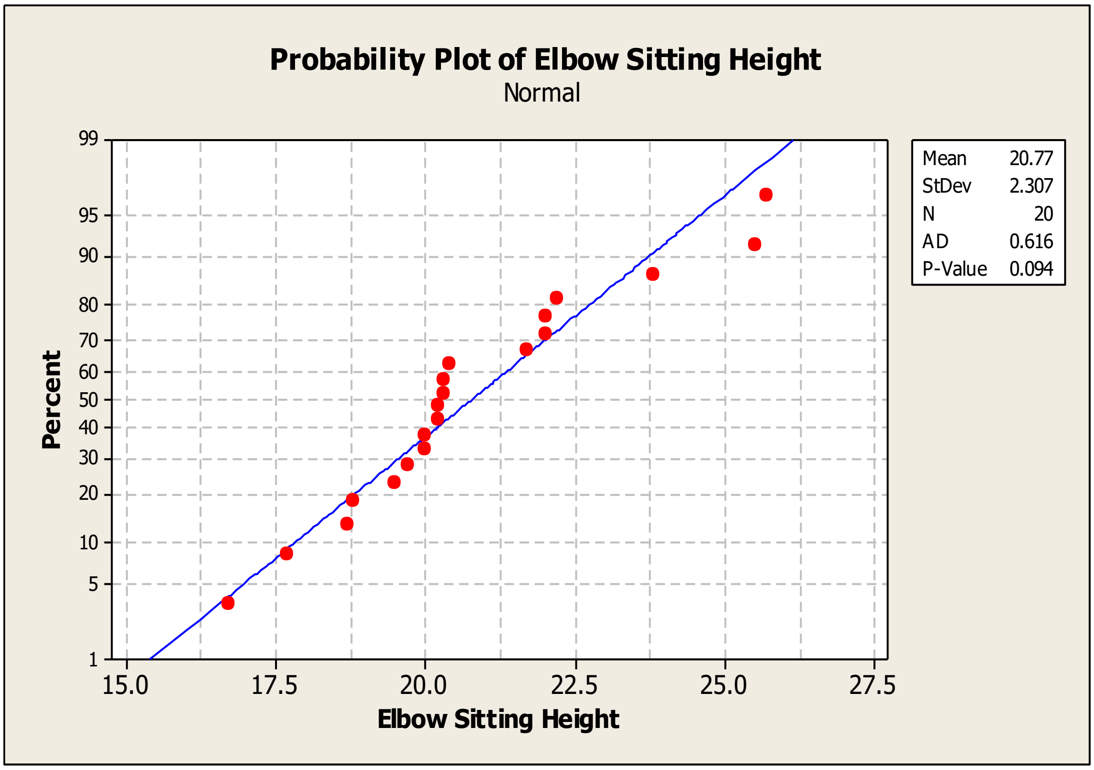

Figure A.6: Normality of Elbow Sitting Height Measurement

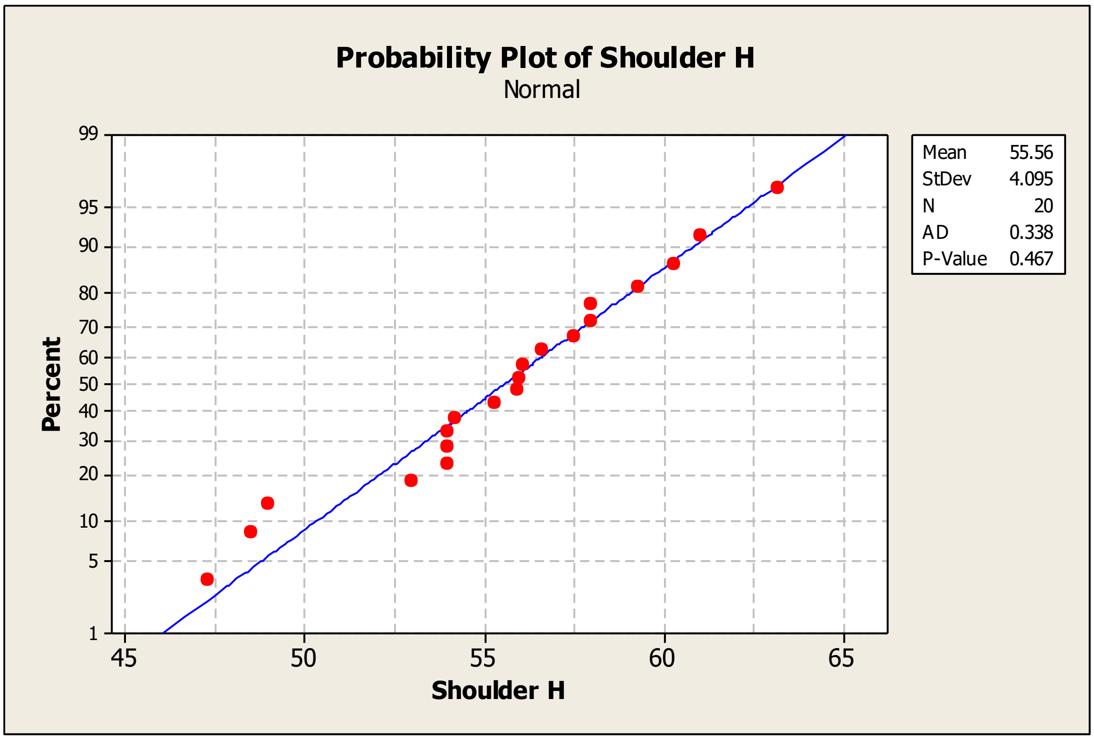

Figure A.7: Normality of Shoulder Height

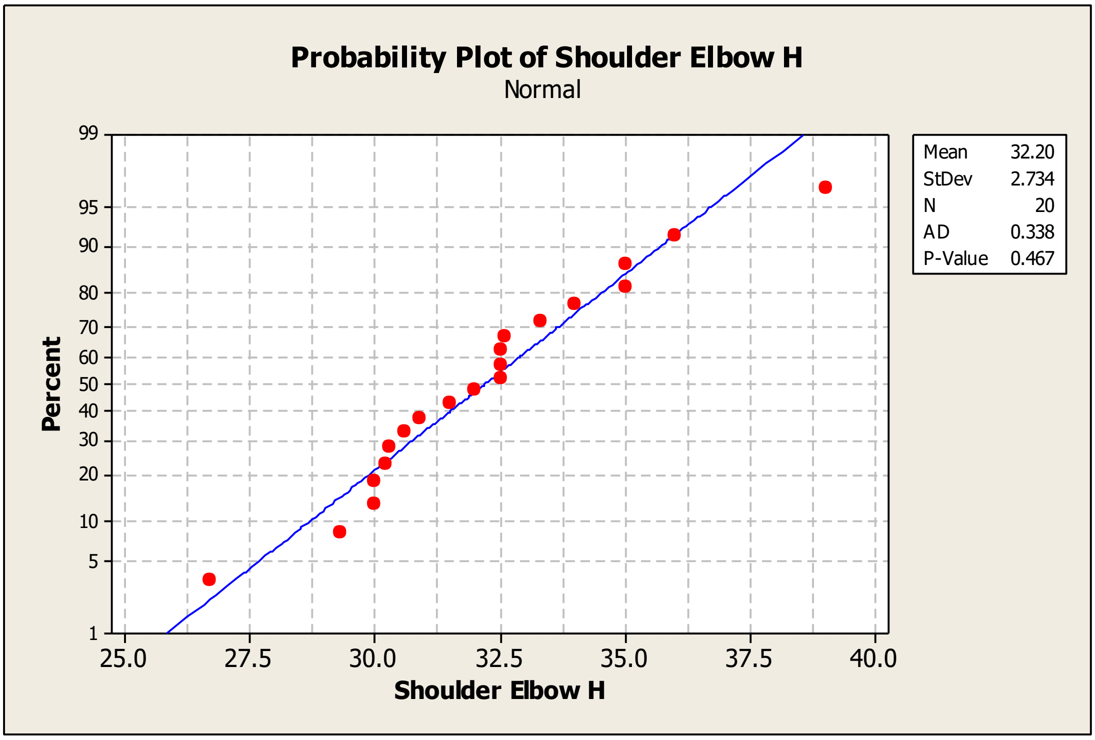

Figure A.8: Normality of Shoulder Elbow Height

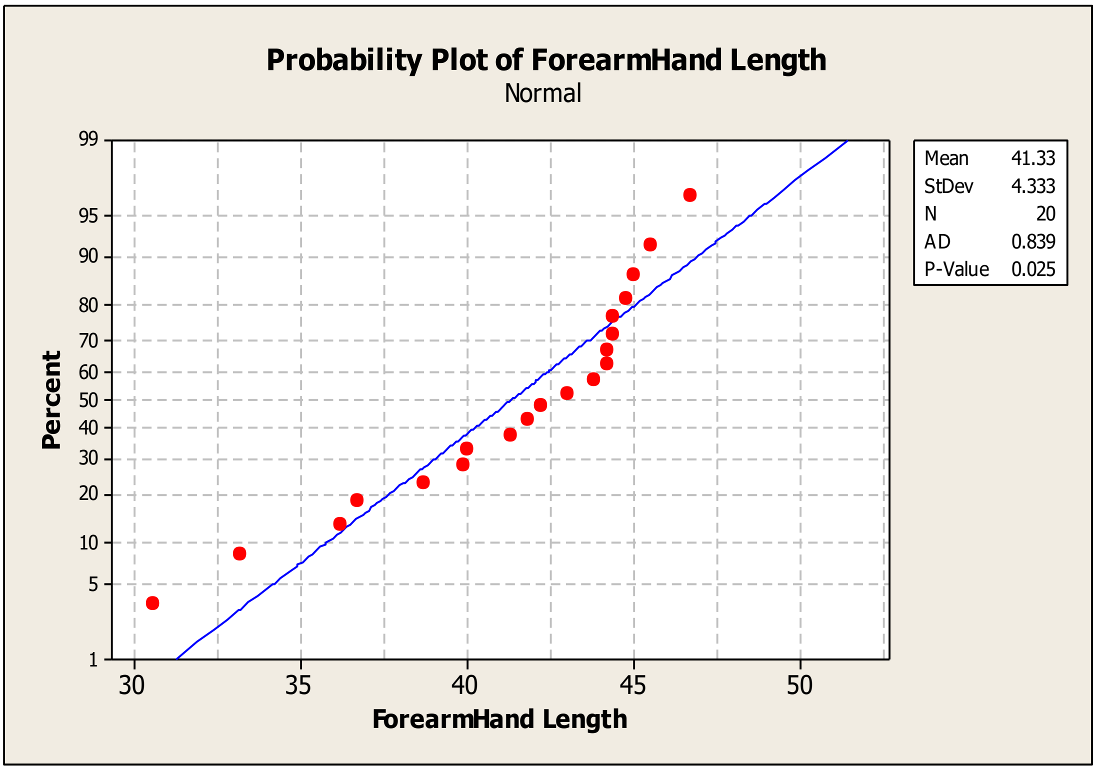

Figure A.9: Normality of ForearmHand Length

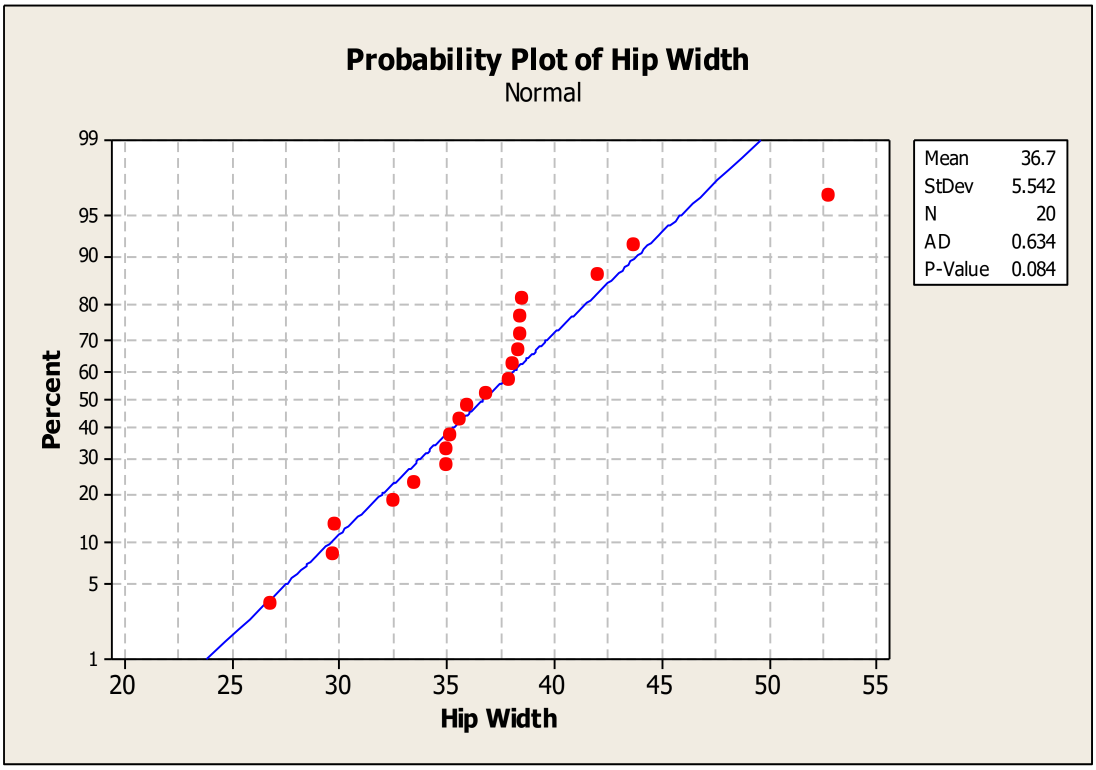

Figure A.10: Normality of Hip Width

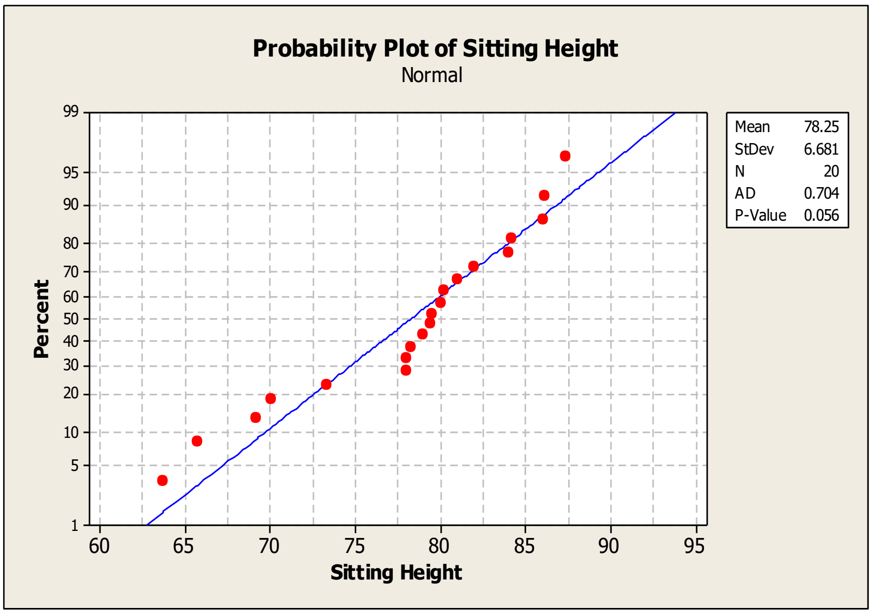

Figure A.11: Normality of Sitting Height

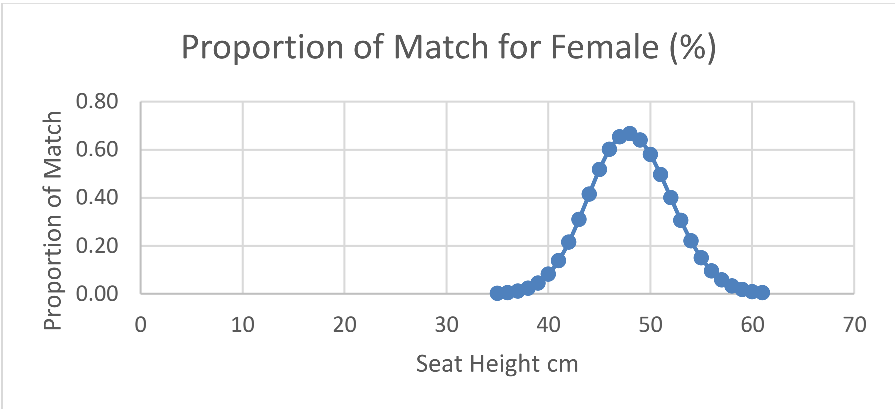

Figure A.12: Proportion of Match at different Seat Height for Female

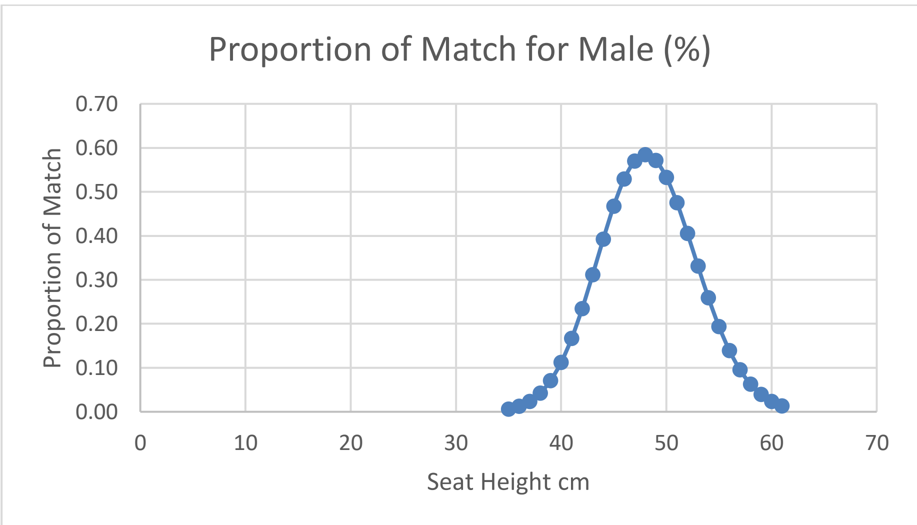

Figure A.13: Proportion of Match at different Seat Height for Male

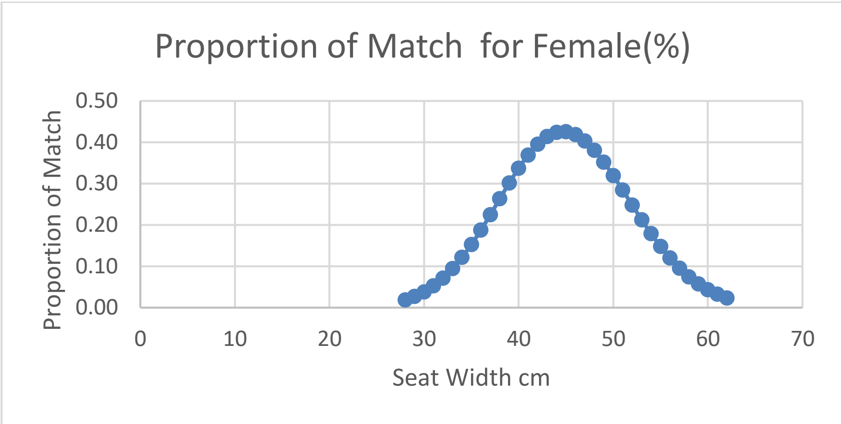

Figure A.14: Proportion of Match at Different Seat Width for female

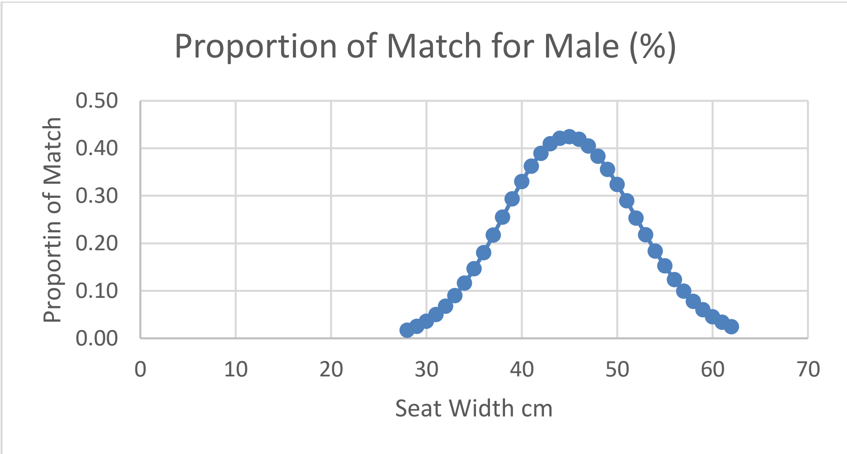

Figure A.15: Proportion of Match at Different Seat Width for Male

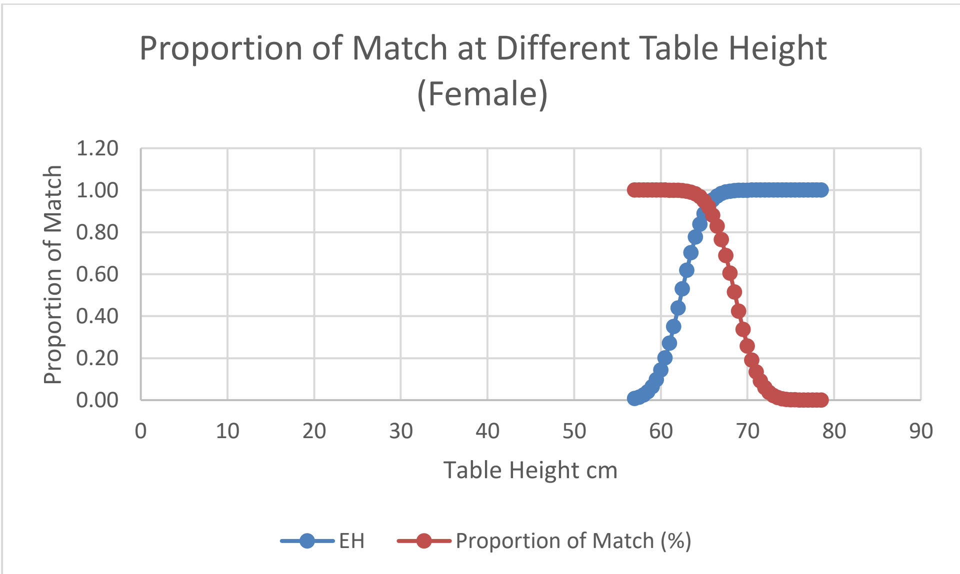

Figure A.16: The Proportion of Match Population at Different Table Height (Female)

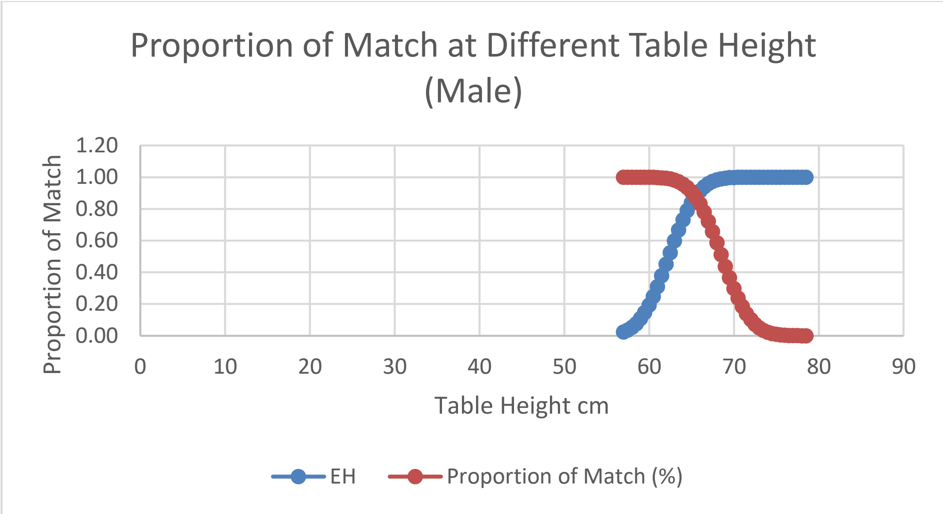

Figure A.17: The Proportion of Match Population at Different Table Height (Male)

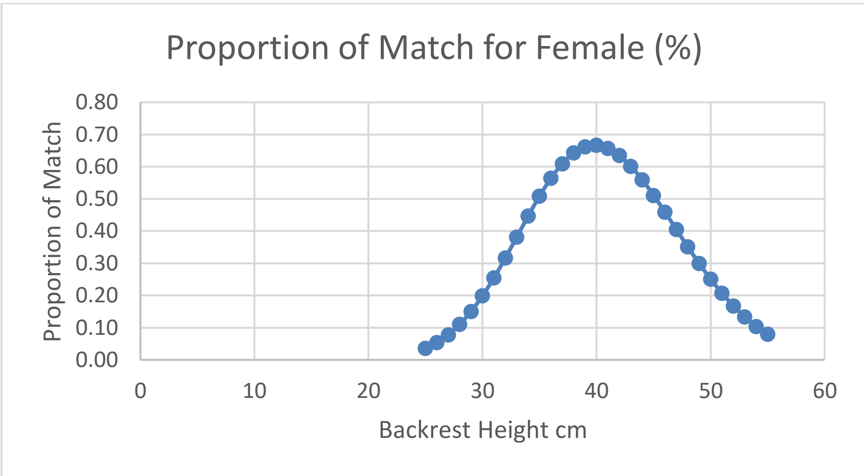

Figure A.18: The Proportion of Match Population at Different backrest Height (Female)

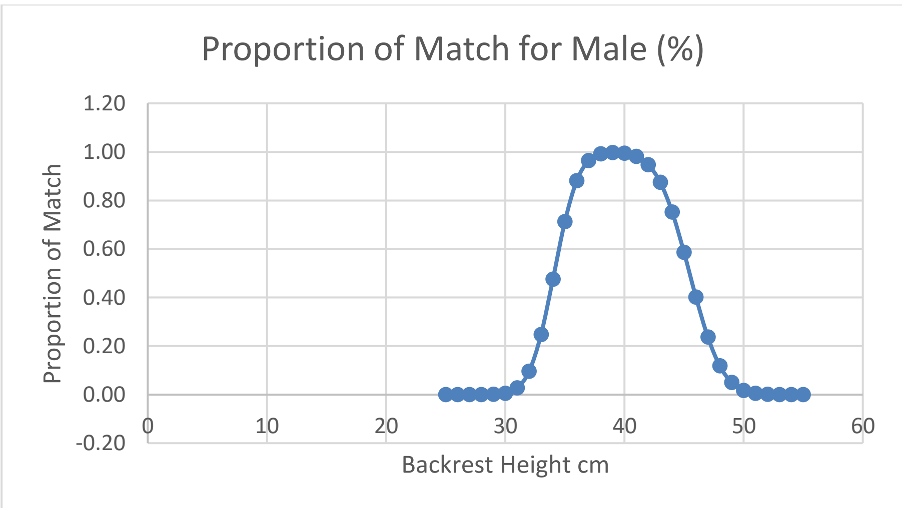

Figure A.19: The Proportion of Match Population at Different backrest Height (Male)

Appendix B: Illumination Measurements At Eastern Mediterranean University Registrar Office

Table B.1: Optec Vision Test Statistics

	Acuity both eyes	Acuity right eye	Acuity left eye	Depth perception	Color perception	Vertical phoria	Lateral phoria	Near Acuity landlot rings(both eyes)	Acuity right eye	Acuity left eye	Lateral phoria
Valid	19	19	19	19	19	19	19	19	19	19	19
Missing	0	0	0	0	0	0	0	0	0	0	0
Mean	7.95	6.26	6.05	5.79	7.47	4.05	9.42	8.42	8.32	6.58	9.61
Median	8.00	6.00	5.00	7.00	8.00	4.00	9.50	11.00	9.00	7.00	9.50
Std. Deviation	3.659	3.984	3.535	3.293	1.172	.598	1.812	4.936	4.435	4.247	2.826
Minimum	3	1	2	0	4	3	6	0	1	0	3
Maximum	14	14	13	9	8	5	13	14	14	13	15

Table B.2: Illuminance Levels, Activity, and Area

Illuminance (Lux)	**Activity**	**Area**
100	Causal seeing	Corridors, changing rooms, stores.
150	Some perception of details	Loading bays, switch rooms, plant rooms.
200	Continuously occupied	Foyers, entrance halls, dining rooms.
300	Visual tasks moderately easy	Libraries, sports halls, lecture theaters.
500	Visual tasks moderately difficult	General offices, kitchens, laboratories, retail shops.
750	Visual tasks difficult	Drawing offices, meat inspection, chain stores.
1000	Visual tasks very difficult	General inspection, electronic assembly, paintwork, supermarkets.
1500	Visual tasks extremely difficult	Fine work and inspection, precision assembly.
2000	Visual tasks exceptionally difficult	Assembly of minute items, finished fabric inspection.

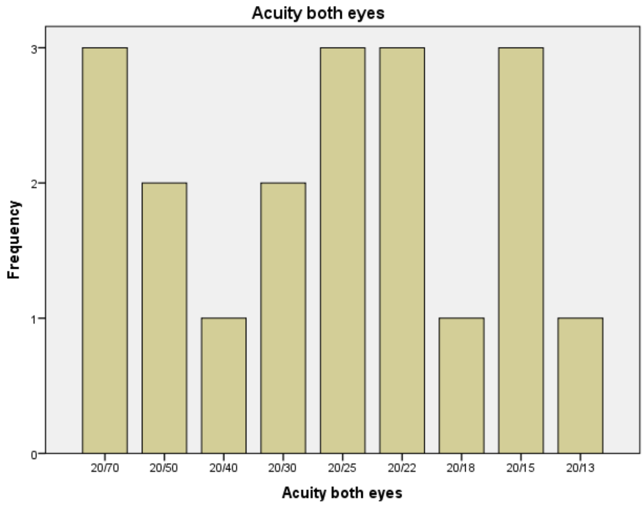

Figure B.1: Acuity Test (Both Eyes – Far Distance)

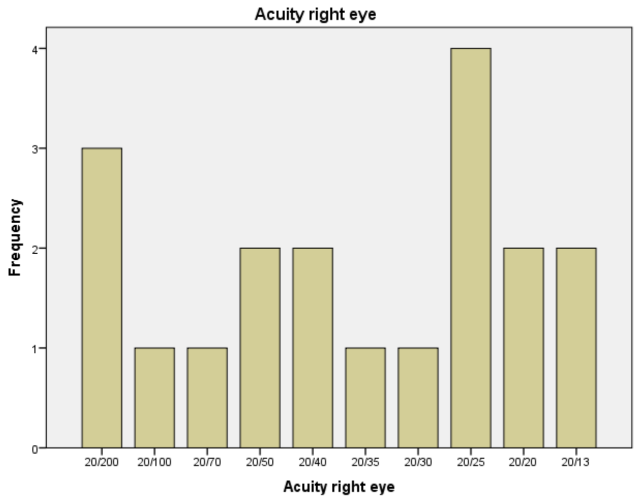

Figure B.2: Acuity Test (Right Eye – Far Distance)

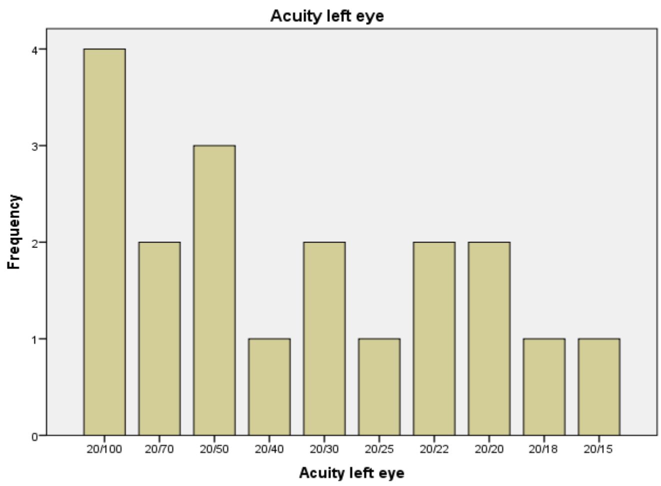

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Figure B.3: Acuity Test (Left Eye – Far Distance)

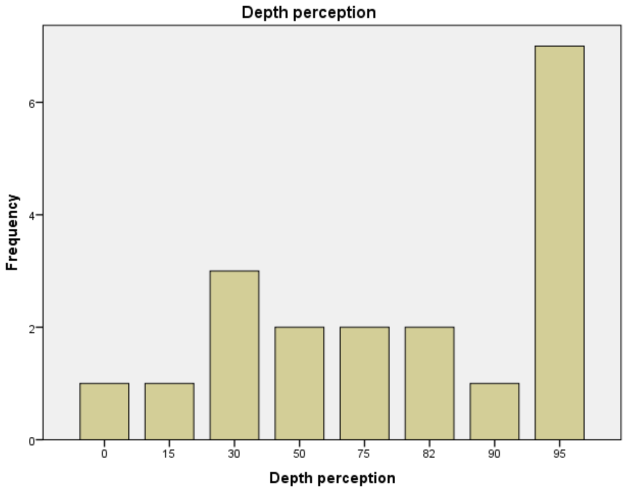

Figure B.4: Depth Perception

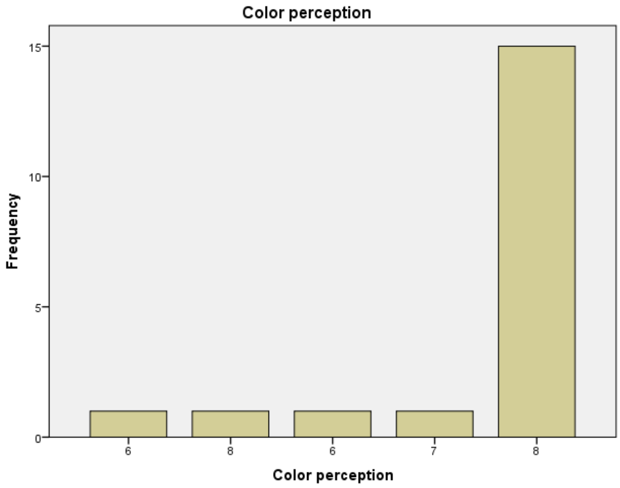

Figure B.5: Color Perception

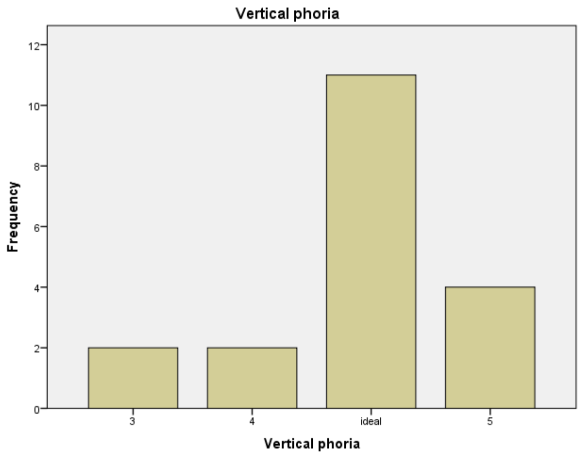

Figure B.6: Vertical Perception

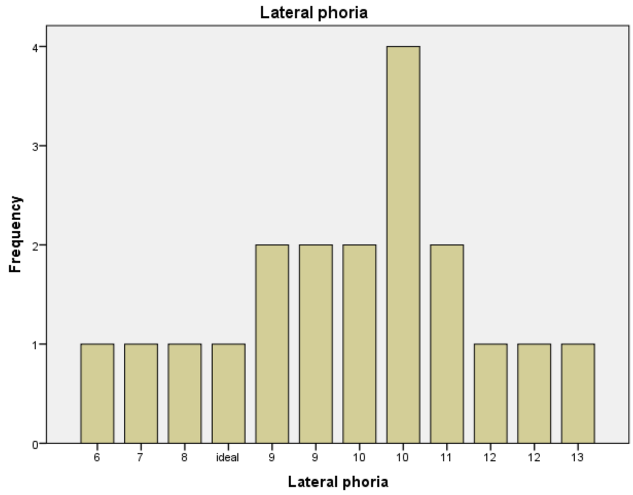

Figure B.7: Lateral Phoria Test

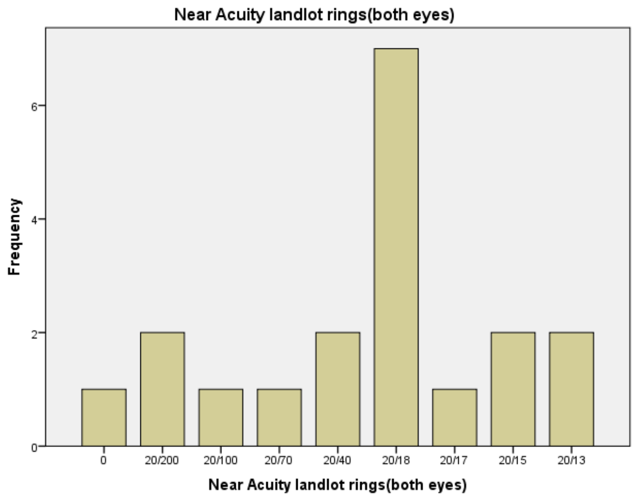

Figure B.8: Acuity Test (Both Eyes – Near Distance)

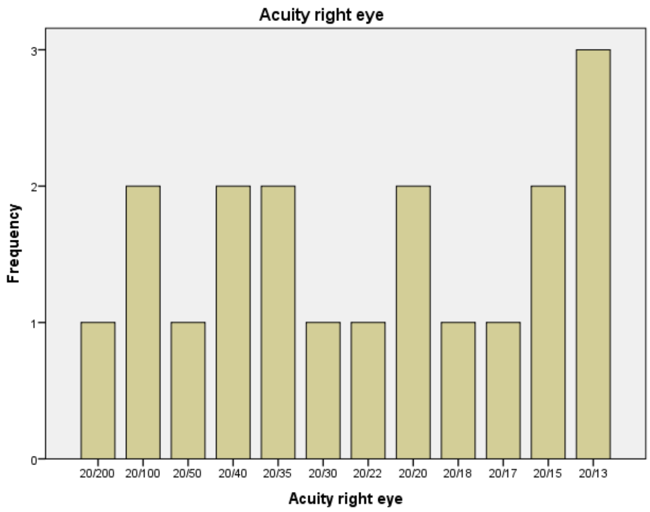

Figure B.9: Acuity Test (Right Eye – Near Distance)

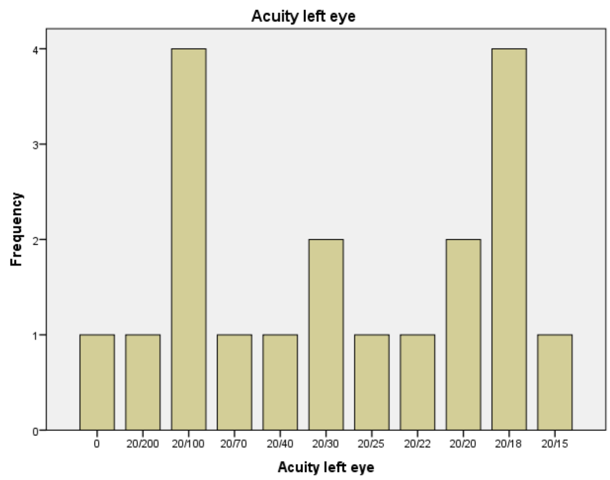

Figure B.10: Acuity Test (Left Eye – Near Distance)

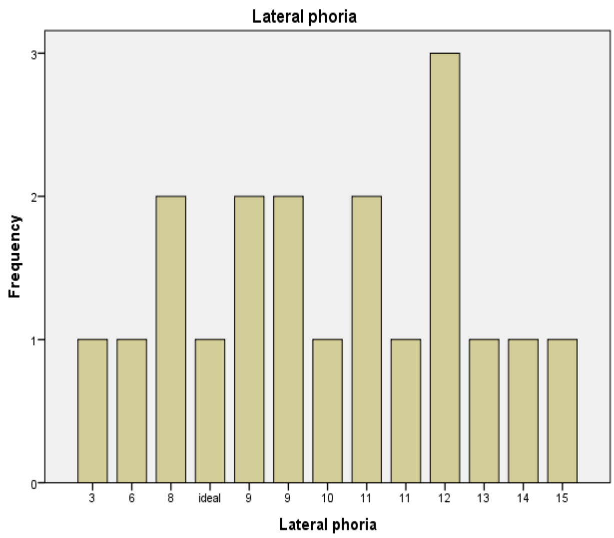

Figure B.11: Lateral Phoria Test (Both Eyes – Near Distance)

Figure B.12: Light Meter (Lux-Meter)

Figure B.13: Anthropometric Ruler

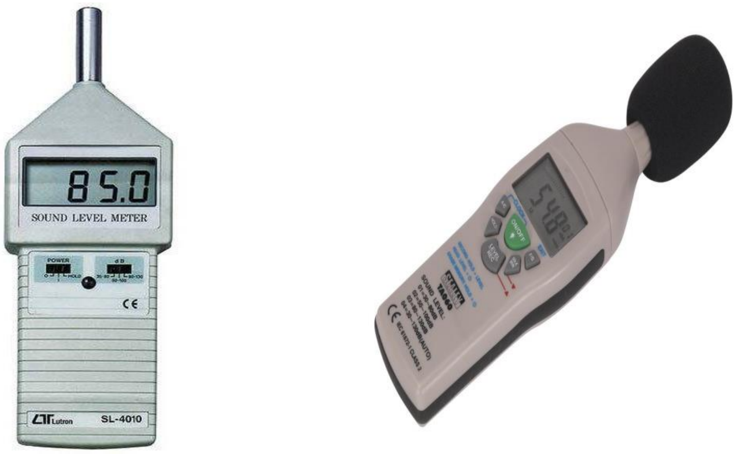

Figure B.14: Sound Level Meters

Figure B.15: Audiometer

Figure B.16: Optec Vision Tester

Appendix C: Noise and Air Conduction Measurements At Eastern Mediterranean University Registrar Office

Table C.1: Audiometer Statistics Results

Day/Time		FRIDAY 10-11	FRIDAY 12-1	FRIDAY 2-3	MONDAY 10-11	MONDAY 12-1	MONDAY 2-3	TUESDAY 10-11	TUESDAY 12-1	TUESDAY 2-3
N	Valid	32	32	32	32	32	32	32	32	32
Mean		59.0938	56.9063	59.4375	52.6250	59.6875	55.9688	55.9688	55.0313	53.7500
Median		60.0000	57.0000	60.0000	52.0000	59.0000	55.0000	56.0000	54.0000	54.0000
Std. Deviation		3.63104	3.60429	3.60052	3.61672	3.11539	4.62451	3.22775	3.50561	3.14181
Minimum		52.00	51.00	50.00	47.00	54.00	48.00	51.00	50.00	47.00
Maximum		64.00	65.00	65.00	61.00	66.00	63.00	63.00	63.00	59.00

Table C.2: Air Conduction Test (Right and Left Ear) at EMU Registrar Office

		Audiogram Frequency in Hertz (Right Ear)										Audiogram Frequency in Hertz (Left Ear)									
Subject	AGE	250	500	750	1000	1500	2000	3000	4000	6000	8000	250	500	750	1000	1500	2000	3000	4000	6000	8000
1	32	25	45	45	40	30	30	20	20	30	30	40	35	35	30	20	30	20	20	15	15
2	33	35	40	35	30	20	20	10	5	25	15	30	40	35	30	30	20	10	20	30	40
3	29	30	30	30	30	25	15	5	5	15	20	35	35	30	25	20	15	15	10	20	20
4	43	30	35	30	25	15	10	10	5	10	10	20	20	25	25	15	10	0	0	5	5
5	33	40	40	45	50	25	20	30	15	30	15	60	40	40	40	35	25	15	30	10	25
6	19	35	35	30	25	20	15	15	10	10	5	30	30	30	20	25	10	10	5	5	15
7	44	40	35	30	30	25	15	20	20	25	15	40	40	30	25	20	15	10	10	15	20
8	38	30	30	35	30	15	10	10	15	10	10	30	35	25	25	15	15	5	15	10	25
9	23	30	30	30	15	15	10	10	10	20	15	25	35	25	15	15	10	5	10	0	5
10	24	35	35	30	20	15	10	10	5	10	10	15	5	-10	0	10	0	5	10	10	5
11	45	35	35	25	30	15	10	15	30	35	60	50	55	50	50	35	40	35	45	45	35
12	36	25	30	30	15	15	10	10	10	15	-10	30	30	25	10	15	5	15	15	20	20
13	55	45	45	40	30	30	30	30	35	50	35	30	40	30	25	20	15	20	20	20	20
14	32	35	35	35	25	15	10	20	5	10	20	25	35	35	20	15	20	5	10	10	20
15	35	35	20	25	25	20	20	5	15	10	20	25	30	30	30	30	15	15	5	20	25
16	40	30	35	35	20	15	15	20	20	15	15	30	30	30	20	20	20	10	20	20	15
17	33	25	30	30	20	15	5	10	15	5	0	20	20	20	10	10	5	5	10	5	5
18	28	50	45	40	40	45	45	30	25	30	35	25	25	20	10	10	5	0	0	20	5
19	26	50	60	55	50	60	65	75	70	75	80	40	50	45	50	65	70	70	80	80	85

Table C.3: Sound Level Statistics Results

	N	Minimum	Maximum	Mean	Std. Deviation
FRIDAY10	32	52.00	64.00	59.0938	3.63104
FRIDAY12	32	51.00	65.00	56.9063	3.60429
FRIDAY2	32	50.00	65.00	59.4375	3.60052
MONDAY10	32	47.00	61.00	52.6250	3.61672
MONDAY12	32	54.00	66.00	59.6875	3.11539
MONDAY2	32	48.00	63.00	55.9687	4.62451
TUESDAY10	32	51.00	63.00	55.9688	3.22775
TUESDAY12	32	50.00	63.00	55.0313	3.50561
TUESDAY2	32	47.00	59.00	53.7500	3.14181

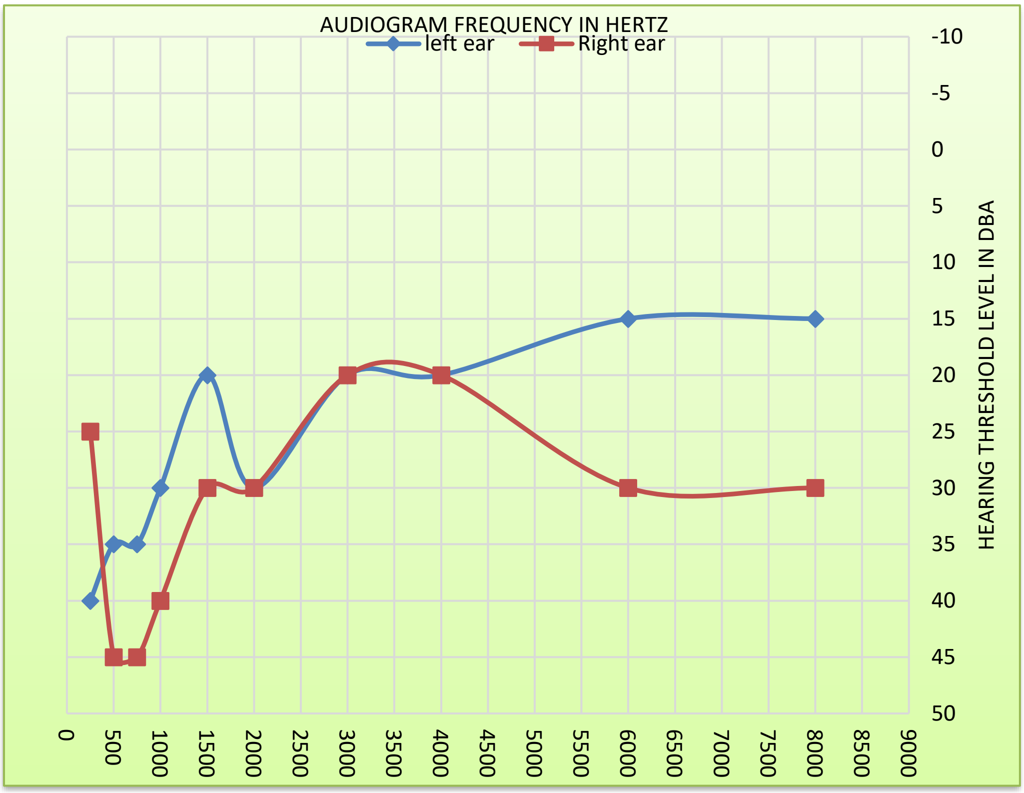

Figure C.1: Audiogram Air Conduction Test

Mild Hearing loss

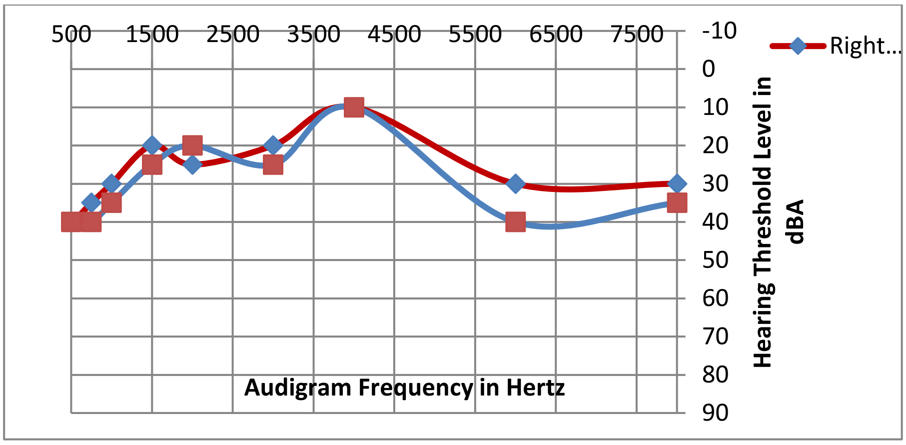

Figure C.2: Audiogram Air Conduction Test
Mild Hearing Loss

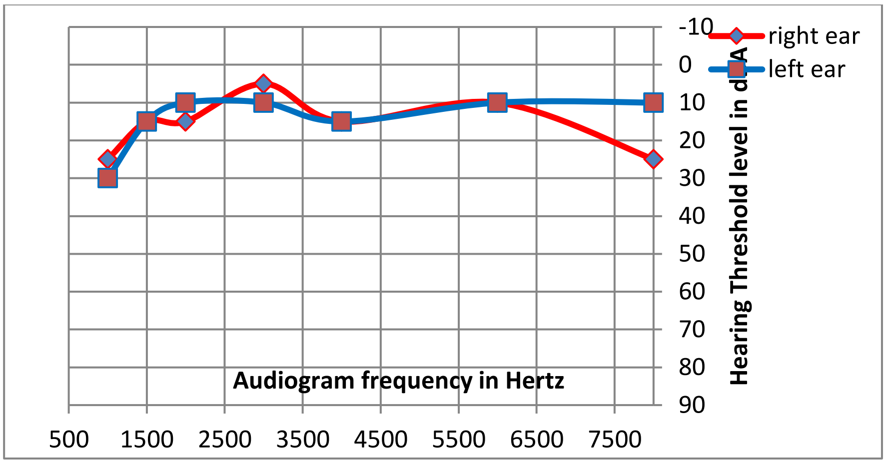

Figure C.3: Audiogram Air Conduction Test
Normal Level

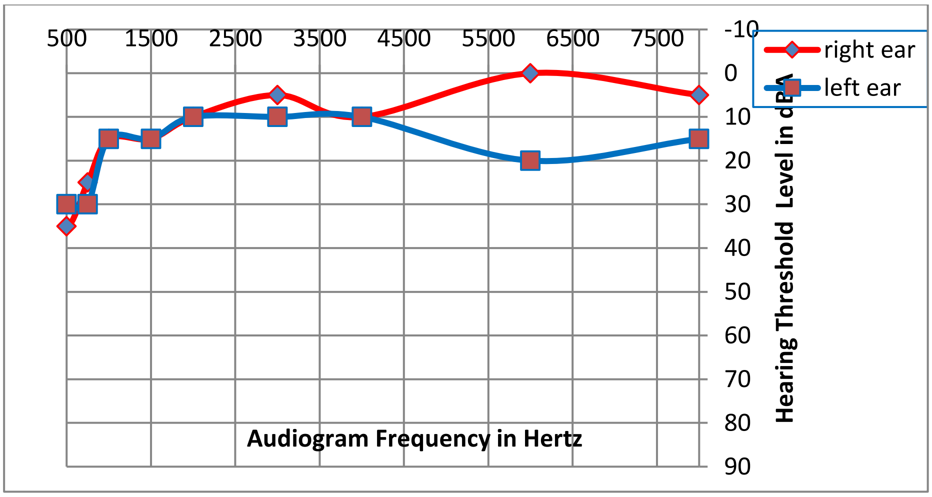

Figure C.4: Audiogram Air Conduction Test
Normal Level

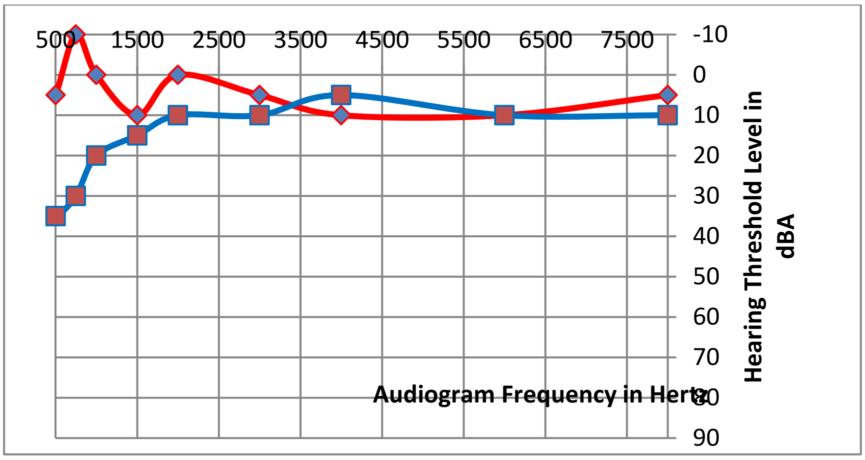

Figure C.5: Audiogram Air Conduction Test
Normal Level

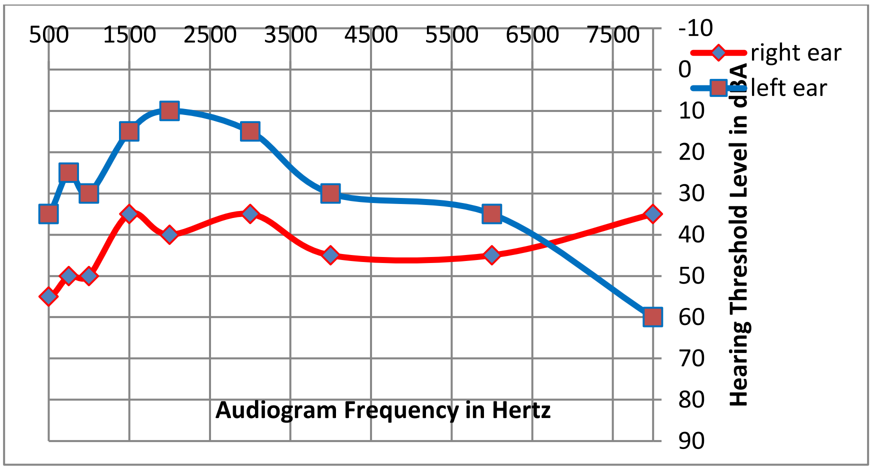

Figure C.6: Audiogram Air Conduction Test
Moderate Hearing Loss

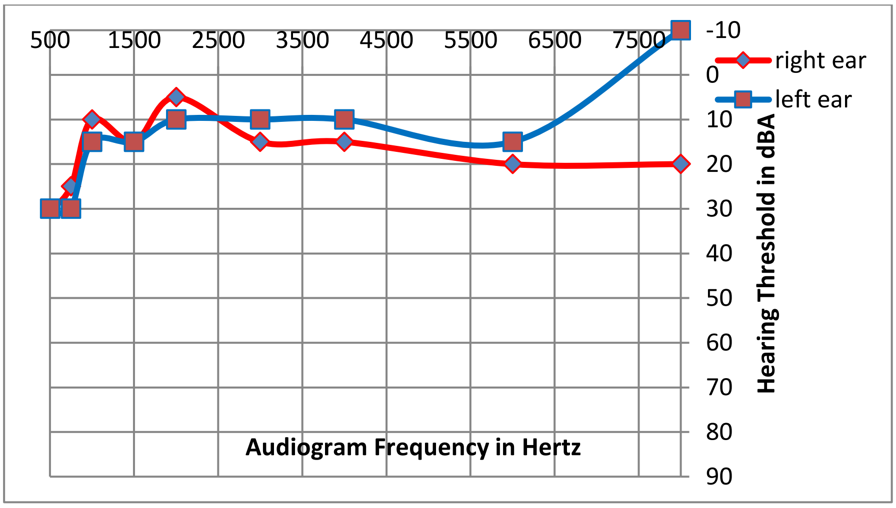

Figure C.7: Audiogram Air Conduction Test

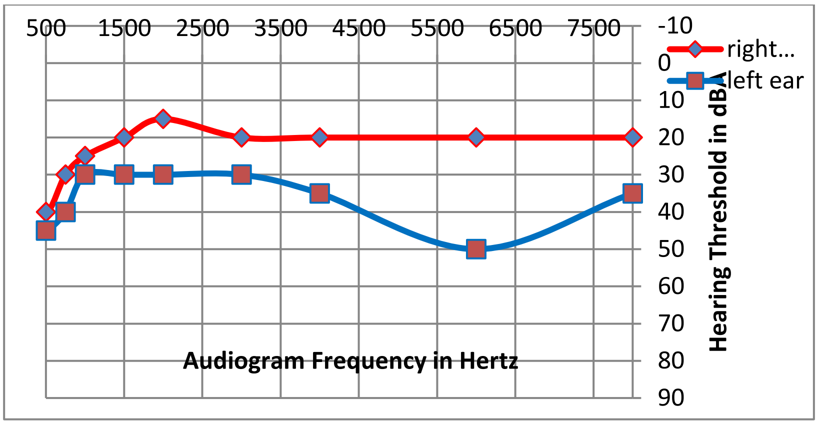

Figure C.8: Audiogram Air Conduction Test
Normal Right Ear and Mild Left Ear

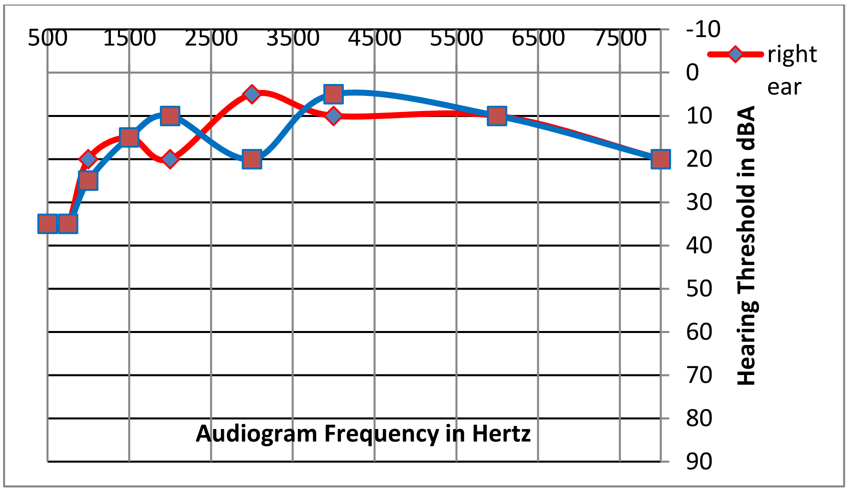

Figure C.9: Audiogram Air Conduction Test
Normal Level

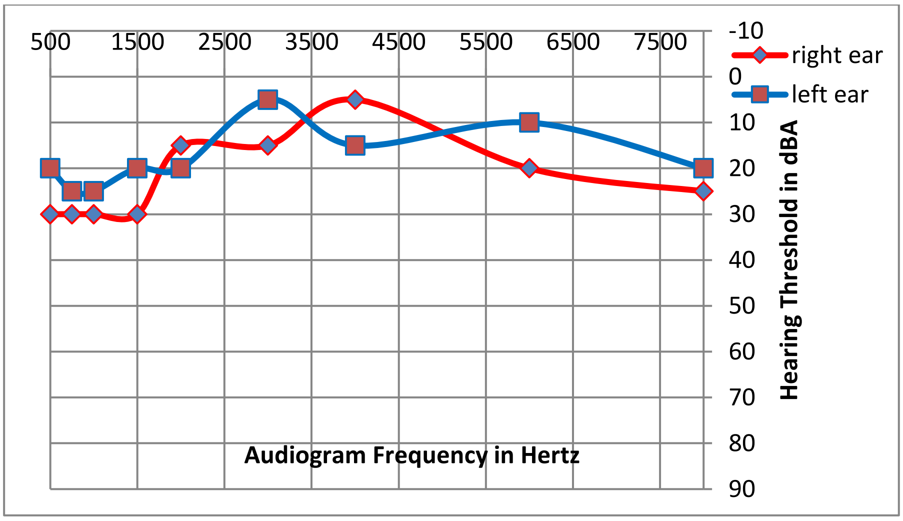

Figure C.10: Audiogram Air Conduction Test
Normal Left Ear and Mild Right Ear

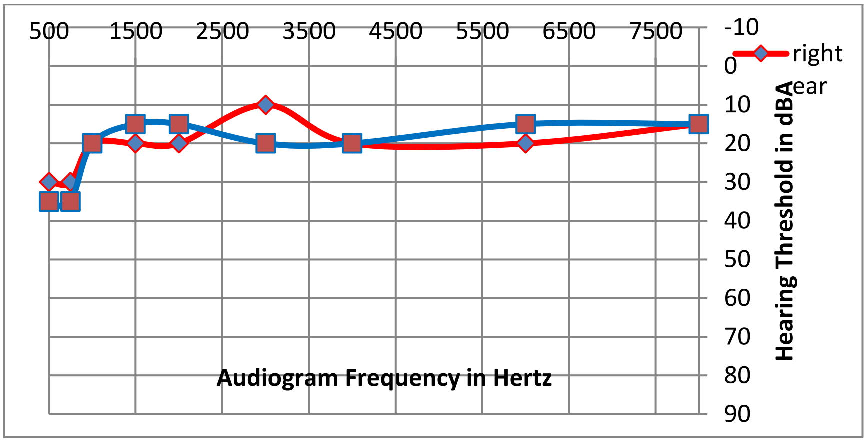

Figure C.11: Audiogram Air Conduction Test
Normal Level

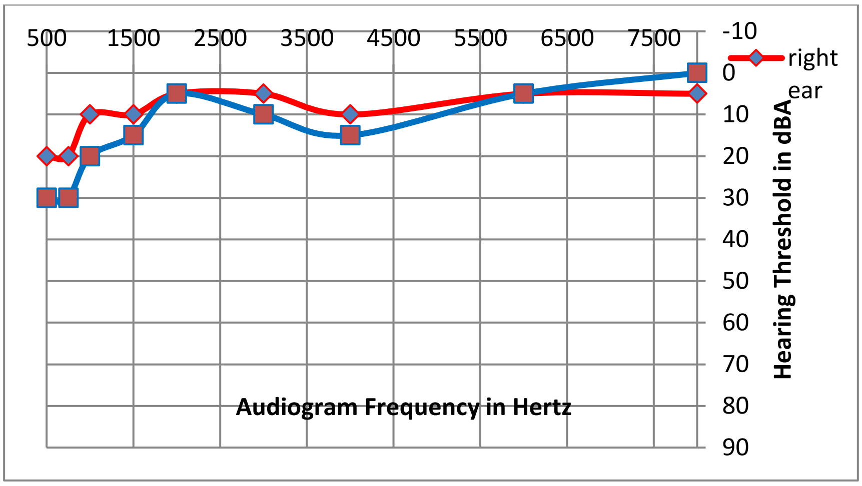

Figure C.12: Audiogram Air Conduction Test
Normal Level

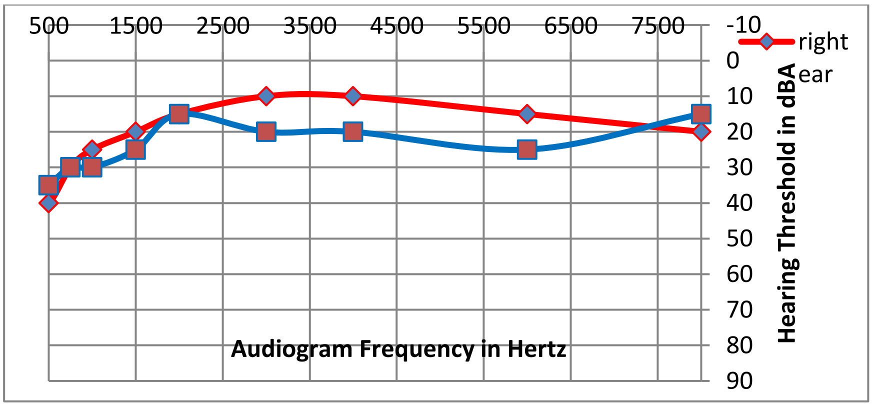

Figure C.13: Audiogram Air Conduction Test
Normal Right and Mild Left Ear

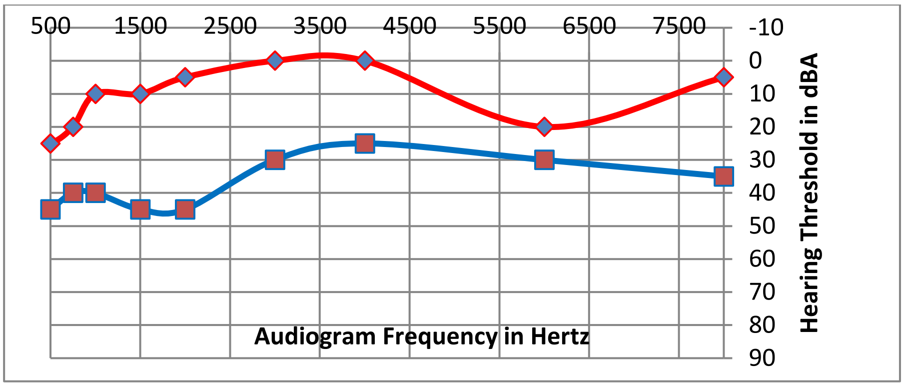

Figure C.14: Audiogram Air Conduction Test
Normal Right and Mild Left

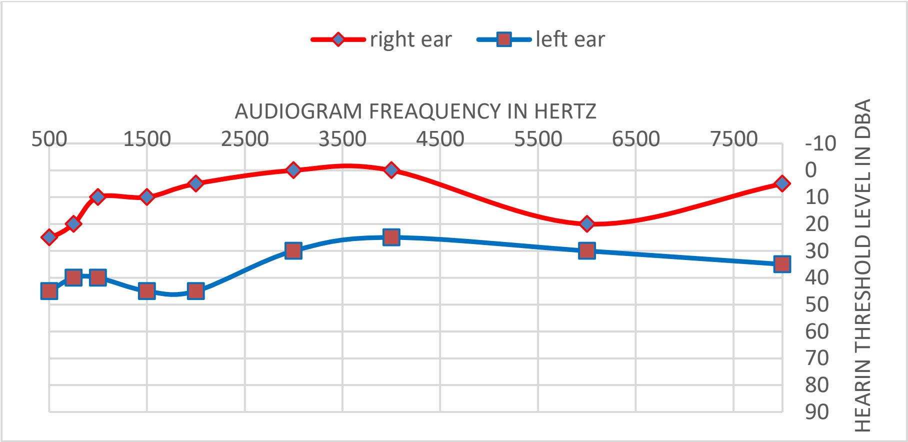

Figure C.15: Audiogram Air Conduction Test
Normal Right and Mild Left Ear

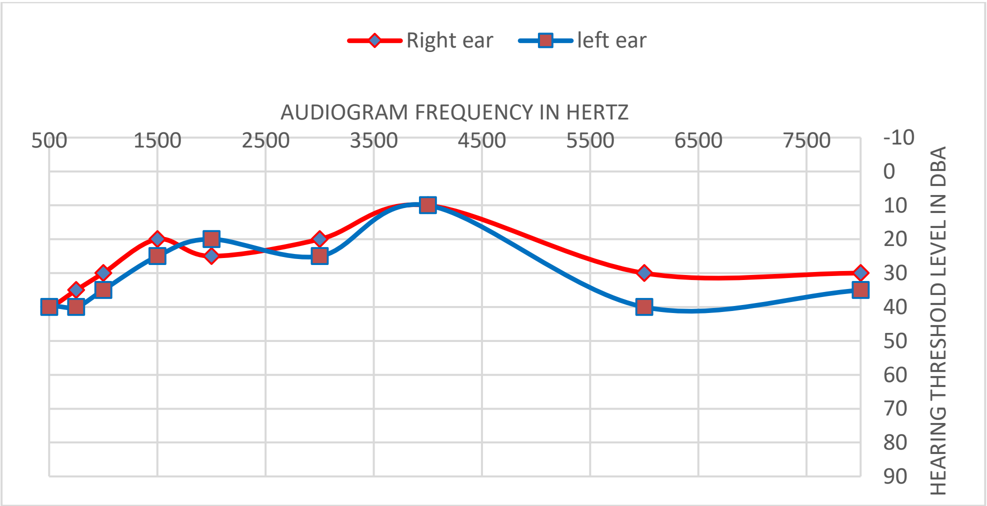

Figure C.16: Audiogram Air Conduction Test
Mild hearing Loss

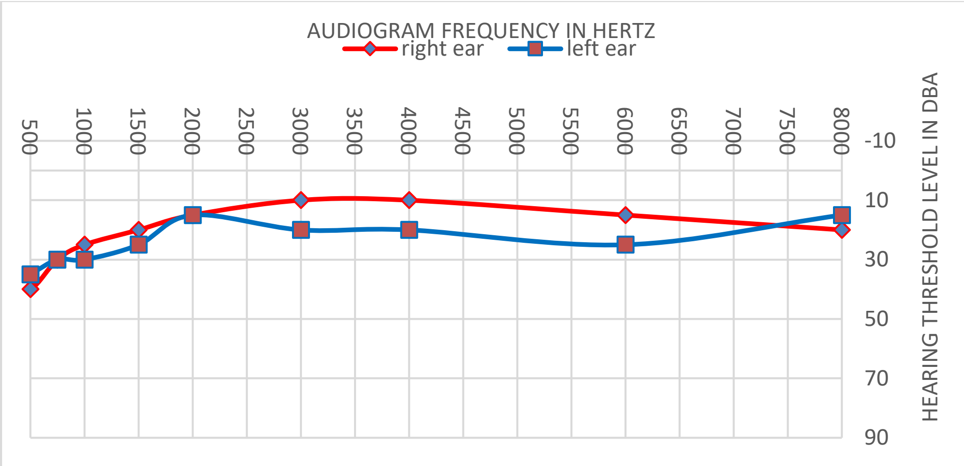

Figure C.17: Audiogram Air Conduction Test
Mild Hearing Loss(Left Ear), and Normal Right Ear

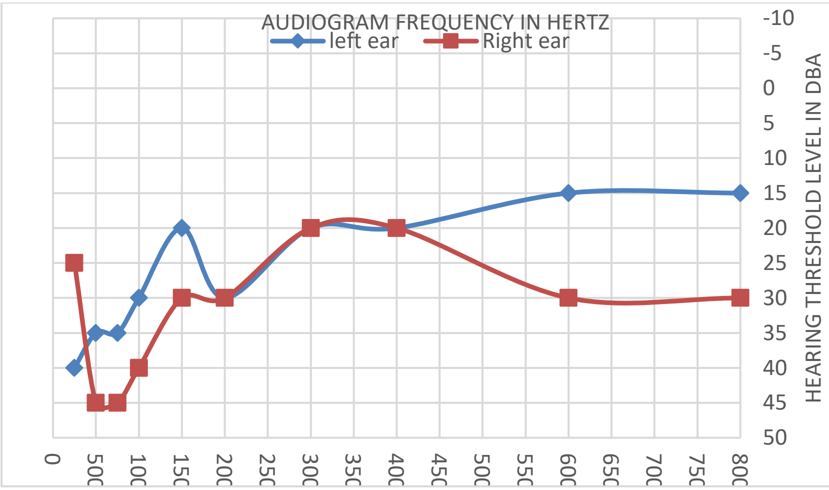

Figure C.18: Audiogram Air Conduction Test
Moderate Hearing Loss

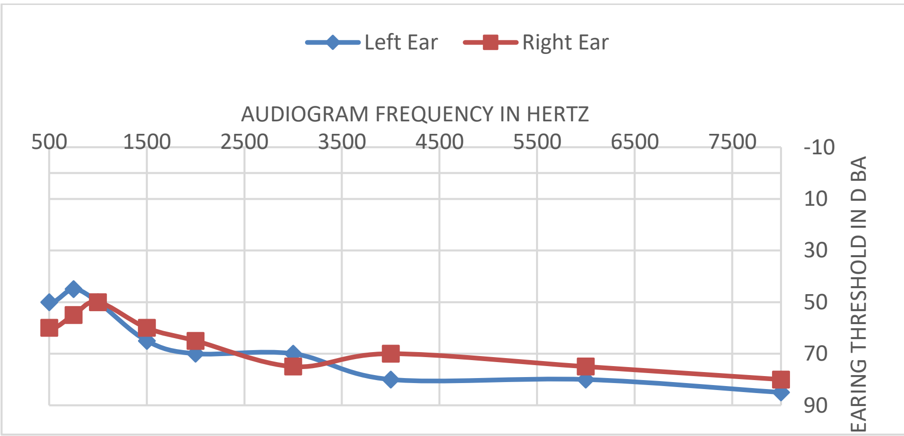

Figure C.19: Audiogram Air Conduction Test
Severe Hearing Loss

Appendix D: Questionnaire

Doğu Akdeniz Üniversitesi
"Uluslararası Kariyer İçin"
Eastern Mediterranean University
"For Your International Career"
P.K.: 99628 Gazimağusa, KUZEY KIBRIS / Famagusta, North Cyprus, via Mersin-10 TURKEY
Tel: (+90) 392 630 1995
Faks/Fax: (+90) 392 630 2919
bayek@emu.edu.tr

Etik Kurulu / *Ethics Committee*

Reference No: ETK00-2017-0171 25.05.2017

RE: Mohammad A. Kh. Hamdan (16500161)
Department of Industrial Engineering

To Whom It May Concern,

As part of the 2016-2017 Spring Semester, pertaining to Master Thesis questionnaires EMU's Scientific Research and Publication Ethics Committee has granted Mr. Mohammad A. Kh. Hamdan (16500161), from the Department of Industrial Engineering Master Graduate Program, to pursue with his survey entitled ***Human Safety at EMU Registrar Office***. This decision has been taken by the majority of votes.
(Meeting number 2017/43-04)

Regards,

EASTERN MEDITERRANEAN UNIVERSITY ETİK KURULU ★ ETHICS COMMITTEE 1979 Gazimağusa North Cyprus

Assoc. Prof. Dr. Şükrü Tüzmen
Director of Ethics Commitee

Questionnaire

You are being invited to answer the questionnaire below about Human Safety at EMU. There are no risks for your participation in this research study. However, your contribution to this research will be highly appreciated. The information you provide will help us to learn more about people's experience in administration offices, and human safety.

The Department of Industrial Engineering at EMU may inspect these records. In all other respects, However, the data will be held in confidence to the extent permitted by law. Should the data be published, your identity will not be disclosed.

Please, remember that your participation in this study is voluntary. By completing the questionnaire you are voluntarily agreeing to participate. You are also indicating that the questions below have been answered in a language you can understand. All future questions will be treated in the same manner.

If you have any questions about this study, please feel free to call or email Mr. Mohammad Hamdan (0533-8404851) (alatrash@najah.edu).

1. Gender : Male. ☐ Female ☐
2. **Age** (year)
   - ☐ 20 – 25 years
   - ☐ 26 – 31
   - ☐ 32 – 37
   - ☐ 38 – 43
   - ☐ 44 – 49
   - ☐ 50 – 56
   - ☐ More than 56 years
3. **Height** in (cm's)
   - ☐ Shorter than 150 cm
   - ☐ 150 – 160
   - ☐ 161 – 170
   - ☐ 171 – 180

- ☐ 181 – 190
- ☐ 191 – 200
- ☐ More than 200 cm

4. **Weight** in (Kg)
   - ☐ Less than 40 kg
   - ☐ 40 - 50
   - ☐ 51 – 60
   - ☐ 61 – 70
   - ☐ 71 – 80
   - ☐ 81 – 90
   - ☐ More than 91 kg

5. Working years (year)
   - ☐ Less than 1 year
   - ☐ 2 – 3
   - ☐ 4 – 5
   - ☐ 6 – 7
   - ☐ 8 – 9
   - ☐ 9 – 10
   - ☐ More than 10 years

6. Working hours/day
   - ☐ Less Than 1 hour
   - ☐ 1 – 2
   - ☐ 3 – 4
   - ☐ 5 – 6
   - ☐ 7 – 8
   - ☐ More than 8 hours

7. Computer using (hours/day)

☐ Less than 1 hour

☐ 1 – 2

☐ 3 – 4

☐ 5 – 6

☐ 7 – 8

☐ More than 8 hours

8. Working hours per week

☐ Less than 5 hours

☐ 05 – 12

☐ 13 – 20

☐ 21 – 28

☐ 29 – 36

☐ More than 36 hours

9. During the past 6 months, have you experienced or felt any of the following situation

region/symptoms	Ache	Pain	Cramp	Tingling	Numbness	Swilling
Neck	☐	☐	☐	☐	☐	☐
Shoulder	☐	☐	☐	☐	☐	☐
Elbow/forearm	☐	☐	☐	☐	☐	☐
Hand/wrist	☐	☐	☐	☐	☐	☐
Finger	☐	☐	☐	☐	☐	☐
Upper back	☐	☐	☐	☐	☐	☐
Lower back	☐	☐	☐	☐	☐	☐

10. Regarding vision function, do you think that a vision is appropriate and sufficient ?

☐ Yes ☐ No

11. Regarding your hearing function, do you think that the quietness in your work place is sufficient ?

☐ Yes ☐ No

12. Regarding sitting function, do you think that your work seat is comfortable ?

☐ Yes ☐ No

13. Do you think the lighting in your working place is sufficient ?

☐ Yes ☐ No

14. Do you think that break- time is useful ?

☐ Yes ☐ No

15. Are you involved in any of the following sports activities?(if yes, mark it/them)?

☐ Walking or jogging

☐ Football

☐ Basketball

☐ Volleyball

☐ Tennis

☐ Swimming

☐ Other, please specify

16. Do you exercise ?

☐ Never

☐ Rarely

☐ Sometimes

☐ Often